ANNAMALAI UNIVERSITY

(Affiliated Colleges)

402 - M.Sc. Statistics

Programme Structure and Scheme of Examination (under CBCS)
(Applicable to the candidates admitted from the academic year 2023 -2024 onwards)

Part	Course Code	Study Components & Course Title	Credit	Hours/ Week	Maximum Marks		
					CIA	ESE	Total
		SEMESTER – I					
A	23PSTAC11	**Core - I:** Real Analysis and Linear Algebra	5	7	25	75	100
	23PSTAC12	**Core - II:** Sampling Methods	5	7	25	75	100
	23PSTAC13	**Core - III:** Distribution Theory	4	6	25	75	100
	23PSTAE14-1 23PSTAE14-2	**Elective – I :** Categorical Data Analysis (or) Population Studies	3	5	25	75	100
	23PSTAE15-1 23PSTAE15-2	**Elective-II :** Bayesian Inference (or) Clinical Trials	3	5	25	75	100
		Total	**20**	**30**			**500**
		SEMESTER – II					
A	23PSTAC21	**Core - IV:** Estimation Theory	5	6	25	75	100
	23PSTAC22	**Core - V:** Measure and Probability Theory	5	6	25	75	100
	23PSTAC23	**Core - VI:** Time Series Analysis	4	6	25	75	100
	23PSTAE24-1 23PSTAE24-2	**Elective – III :** Actuarial Statistics (or) Simulation Analysis	3	4	25	75	100
	23PSTAE25-1 23PSTAE25-2	**Elective – IV :** Survival Analysis (or) Econometrics	3	4	25	75	100
B (i)	23PSTAS26	**Skill Enhancement Course (SEC-I):** Statistics Practical – I (Practical)	2	4	25	75	100
		Total	**22**	**30**			**600**

		SEMESTER – III					
A	23PSTAC31	**Core - VII:** Testing of Statistical Hypothesis	5	6	25	75	100
	23PSTAC32	**Core - VIII:** Multivariate Statistical Analysis	5	6	25	75	100
	23PSTAC33	**Core – IX (Industry Module):** Statistical Quality Control	5	6	25	75	100
	23PSTAP34	**Core - IX :** Statistics Practical - II	4	6	25	75	100
	23PSTAE35-1 23PSTAE35-2	**Elective–V :** Operations Research (or) Database Management System	3	3	25	75	100
B(i)	23PSTAS36	**Skill Enhancement Course (SEC-II):** Computational Statistics Using Python	2	3	25	75	100
B(ii)	23PSTAI37	Summer Internship*	2	-	25	75	100
		Total	**26**	**30**			**700**
		SEMESTER – IV					
A	23PSTAC41	**Core - XI:** Design of Experiments	5	6	25	75	100
	23PSTAC42	**Core - XII:** Stochastic Processes	5	6	25	75	100
	23PSTAD43	Project with Viva-Voce	7	10	25	75	100
	23PSTAE44	**Elective – VI** (20% Theory + 80% Practical) ****** Statistics Practical-III (Practical)	3	4	25	75	100
B(i)	23PSTAS45	**Skill Enhancement Course (SEC-III):** Computational Statistics Using R	2	4	25	75	100
C	23PSTAX46	Extension Activity	1	-	100	-	100
		Total	**23**	**30**			**600**
			91				**2400**

* Students should complete two weeks of internship before the commencement of III semester.

** Evaluation is to be done both for theory (15 marks) and practical (60 marks) components separately by the examiners who will be conducting the practical and the marks should be awarded out of 75. Questions for the theory and practical are to be set by the concerned examiner.

Component-wise Credit Distribution

Part	Courses	Sem I	Sem II	Sem III	Sem IV	Total
A	Core (including Practical and Project)	14	14	19	17	**64**
	Elective	6	6	3	3	**18**
B(i)	Skill Enhancement Course	-	2	2	2	**6**
B(ii)	Summer Internship	-	-	2	-	**2**
C	Extension Activity	-	-	-	1	**1**
						91

Part A and B(i) component will be taken into account for CGPA calculation for the post graduate programme and the other components Part B(ii) and C have to be completed during the duration of the programme as per the norms, to be eligible for obtaining PG degree.

Programme Outcomes (PO) and Programme specific outcome (PSO)

The student post graduated in Statistics under the M.Sc. Statistics Programme should be able to have

Programme Outcomes (Pos)	**PO1: Disciplinary Knowledge:** a good theoretical knowledge of the domain Statistics and its methods and techniques. **PO2: Mathematical knowledge:** sharpening mathematical knowledge needed to understand higher levels of Statistics understand multidimensional issues of data. **PO3: Application knowledge:** understanding application of Statistics in various domain. Also understand the interdisciplinary nature of Statistics while applying it. Industrial oriented programming languages are introduce to undertake and solve practical problem in industry. **PO4: Critical Thinking:** examine basic statistical issues in a more logical and methodical manner in a real data given. **PO5: Analytical Reasoning:** to develop capability to identify logical issues in practicing with data, analyze and synthesize data from a variety of sources and accordingly drawconclusions. To acquire capacity for taking central and state government comparative examination (UGC NET, SET, SLET, TNPSC, SSC, TRB, RBI, UPSC, ISS/IES,ICMR,ICAR etc..) **PO6: Problem Solving skills:** The students will be able to examine various hypotheses involved, and will be able to identify and consult relevant resources to find their rationalanswers. Also get mathematical problem solving. **PO7: Research Related Skills:** The students should be able to develop original thinking for formulating new problems and providing their solutions. **PO8: Computational skills:** acquire computing skills necessary for solving real life problems in par with the requirement of a job **PO 9 Team work:** experience in team work by engaging in team projects and team assignments. Also have original thinking and creative presentation **PO 10: Communication and soft skills:** Interactive skills and presentation skills

Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions. **PSO 2 - Entrepreneur** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PSO3 – Research and Development** Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO 5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

Core-I	23PSTAC11: Real Analysis and Linear Algebra	Credit	5
I Year		Hours/ Week	7
I Semester			

Pre-requisite

Undergraduate level vector algebra and matrix theory.

Objectives of the Course

1. To provide recollection as well as building mathematical foundation in real analysis and matrix theory.
2. To understand concepts and definition of metric space and theorems related to it.
3. To know integration and differentiation concepts and its application, to know real functions in one variable as well as several variables, understand it on numerical problems.
4. To know linear space and its basis. Rank of a matrix, characteristic roots and its multiplicity, different types of inverses, numerical examples and real life application.
5. To know different types of matrices, orthogonality, canonical forms, decomposition of matrix, quadratic forms, numerical examples and real life applications.

Course Outline

Unit I: Metric Space – open, closed sets – Intervals (rectangles), Real valued Continuous functions- Discontinuities - compact sets, Bolzano – Weirstrass theorem, Heine – Borel theorem.

Unit II: Derivatives - maxima and minima - Riemann integral & Riemann – Stieltjes integral with respect an increasing integrator – properties of R.S. integral. Functions of several variables, constrained and unconstrained maxima – minima of functions, partial and total derivatives.

Unit III: Basic properties of matrices (orthogonal, idempotent, Kronecker product, projection operators etc); Linear dependence, independence and rank of a matrix; characteristic roots and polynomial, multiplicity of characteristic roots; Cayley Hamilton theorem; inverse of a matrix and determinants.

Unit IV: Reduction of matrices, Echelon form, Hermite canonical form, diagonal reduction, rank factorization, triangular reduction Jordan form; Symmetric matrices and its properties; Decomposition like, singular value decomposition, spectral decomposition, Cholesky decomposition.

Unit V: Matrix differentiation; Generalized inverse and its properties, Moore-Penrose inverse; Application of g-inverse; Quadratic forms, classification, definiteness, index and signature, extremum; transformation and reduction of quadratic form; applications of quadratic forms.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Rudin, Walter (1976): *Principles of Mathematical Analysis*, McGraw Hill.
2. Apostol, T.M (1985): *Mathematical Analysis*, Narosa, Indian Ed.
3. Graybill, F.A (1983): *Matrices with Application in Statistics*, 2nd ed. Wadsworth.
4. Rao, C.R and Bhimasankaran, P (1992): *Linear algebra*, Tata McGraw Hill Pub. Co. Ltd.
5. Searle, S.R (1982): *Matrix Algebra useful for Statistics*, John Wiley and Sons, Inc.

Reference Books

1. Royden, H.L.(1995): *Real analysis*, 3rd ed. Prentice Hall of India.
2. Rangachari, M.S.(1996): *Real Analysis*, Part 1, New Century Book House.
3. Ash, R.B. (1972): *Real Analysis and Probability*, Academic Press.
4. Biswas, S. (1984): *Topics in Algebra of Matrices*, Academic Publications.
5. David, A. Harville (1997): *Matrix Algebra from a Statistician's Perspective*, Springer.
6. Hoffman, K. and Kunze, R. (1971): *Linear Algebra*, 2nd ed. Prentice Hall, Inc.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Get a Mathematical foundation in Real analysis and Matrix Theory.
2. Get a clear idea about Riemann – Stieltjes integral.
3. Understand concepts in matrix theory -rank and factorization, inverse of matrix, g-inverses and its applications matrix.
4. Solve numerical problems and evaluate and interpret outcome.
5. Analyze real life problems and explore research problems.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	M	M
CO2	S	S	S	S	M	S	M	S	M	M
CO3	S	S	S	M	S	S	M	S	S	M
CO4	M	S	S	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to POs	3.0	3.0	3.0	3.0	3.0

Core-II	23PSTAC12: Sampling Methods	Credit	5
I Year		Hours/ Week	7
I Semester			

Pre-requisite

Undergraduate level Statistical Inference.

Objectives of the Course

1. To enrich the skills of students to get more specialization in various sampling procedures and for adopting the appropriate sampling technique in real life application and survey.
2. To have through knowledge on PPSWR and PPSWOR sampling methods.
3. To understand the concept of stratified sampling and systematic sampling methods.
4. To understand the methods of estimation.
5. To acquire knowledge about multistage sampling.

Course Outline

Unit I: Preliminaries – Simple Random Sampling - PPS selection methods.

Unit II: Midzuno sampling method – PPSWR and PPSWOR sampling methods – Ordered and Unordered estimators.

Unit III: Stratified Sampling – Allocation Problems – Systematic Sampling Methods – Balanced, Modified and Centered systematic sampling methods – Yates corrected estimator.

Unit IV: Ratio Estimation – Unbiased Ratio Type estimators – Regression Estimation - Double Sampling for Ratio and Regression Estimation.

Unit V: Multistage Sampling - Randomized Response Methods – Call Back Techniques.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Sampath, S (2005): *Sampling Theory and Methods*, Narosa Publishing House.
2. Cochran, W.G (1965): *Sampling Techniques*, John Wiley and Sons.

Reference Books

1. Murthy, M.N (1967): *Sampling Theory and Methods*, Statistical Publishing Society, Calcutta.
2. Parimal Mukhopadhyay (2005): *Theory and Methods of Survey Sampling*, Prentice Hall of India.

3. Sukhatme, P.V. Sukhatme, B.V. Sukhatme, S. and Asok, C (1984): *Theory of Sample Surveys with Applications*, IASRI, New Delhi.
4. Daroga Singh and Chaudhary, F.S (2018): *Theory and Analysis of Sample Survey Designs*, New age International Publishers, New Delhi.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. apply basics and advanced levels of sampling methods for different types of data.
2. draw a conclusion about the best sampling procedure.
3. use practical applications of ratio and regression method of estimations.
4. analyse data from multi-stage sampling methods.
5. estimate the hidden responses using randomized response techniques.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	S	S	M	M
CO2	S	S	S	S	M	S	M	M	S	M
CO3	S	M	S	M	S	S	M	S	S	M
CO4	M	S	S	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-III	23PSTAC13: Distribution Theory	Credit	4
I Year		Hours/ Week	6
I Semester			

Pre-requisite

Undergraduate level Mathematics and elementary Discrete and continuous distributions.

Objectives of the Course

1. To provide theoretical knowledge on Probability Distributions.
2. To study the concept and properties of bivariate distributions.
3. To have knowledge on the applications of probability distributions.
4. To acquire the knowledge on deriving its characteristics of distributions.
5. To understand the distributions and properties of order statistics and the distribution of quadratic forms.

Course Outline

Unit I: Detailed Study of Binomial, Poisson, Normal, Exponential, Gamma, Beta and Cauchy distributions (derivations, properties, moments, characteristic function and applications) - Concept of truncated distributions and Compound distribution.

Unit II: Bivariate distribution- Concept of joint, marginal and conditional distribution; Functions of random variables and their distributions- maximum and minimum, sum, difference, product and quotient of random variables; Various techniques of finding distributions of functions of random variables.

Unit III: Non-Central t, F and Chi square distribution - Properties of these distributions - Sampling distributions of mean, correlation and regression coefficients for normal samples (null case).

Unit IV: Order statistics and their distributions and properties, Joint and marginal distributions of order statistics, extreme value and their asymptotic distributions, approximating distributions of sample moment, delta method.

Unit V: Quadratic forms for normal variables, Distribution of quadratic forms, Conditions for independence of quadratic forms and linear forms- Cochran's theorem (Without proof).

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Gibbons (1971): *Non-parametric inference*, Tata McGraw Hill.

2. Rohatgi, V.K. and Ehsanes Saleh, A.K.Md (2010): An Introduction to Probability and Statistics, John Wiley and Sons.

Reference Books

1. Rao, C.R. (2009): Linear Statistical Inference and its Applications, 2nd ed, Wiley Eastern.
2. Mood, A.M. Graybill, F.A. and Boes, D.C. (1974): *Introduction to the Theory of Statistics*, McGraw Hill.
3. Johnson, S. and Kotz (1972): *Distributions in Statistics*, Vol. I, II & III, Hougton & Miffin.
4. Dudewicz, E.J. and Mishra, S.N (1988): Modern *Mathematical Statistics*, John Wiley.
5. Searle, S.R (2014): *Linear Models*, John Wiley.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. understand the knowledge on importance of the random variables and its role in the distribution theory.
2. interpret the properties of special univariate continuous distributions, truncated normal distribution and few non-central distributions.
3. explain the moments for the data come from the univariate and bivariate distributions.
4. interpret the distributions of order statistics with regard to median, sample range and joint distribution of order two.
5. understand the distributions of quadratic forms in normal random variable.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	S	M	S	M	M
CO2	M	S	S	S	S	S	M	S	M	M
CO3	S	S	S	M	S	S	M	S	S	M
CO4	S	S	S	S	S	S	S	S	M	M
CO5	S	S	M	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-I	23PSTAE14-1: Categorical Data Analysis	Credit	3
I Year		Hours/ Week	5
I Semester			

Pre-requisite
Undergraduate level statistical data analysis.

Objectives of the Course
To enrich the skills of students for learning the different models in categorical data.

Course Outline
Unit I: Introduction, Categorical response data, Probability distributions for categorical data, Statistical inference for a proportion, More on statistical inference for discrete data, simple problems.

Unit II: Contingency Tables: Probability structure for contingency tables, Comparing proportions in 2X2 tables, The odds ratio, Chi squared tests of independence, Testing independent for ordinal data, Association in three way tables.

Unit III: Generalized Linear Models: Components of a generalized linear model, Generalised linear model for binary data, Generalised linear models for count data, Statistical inference and model checking.

Unit IV: Logistic Regression: Interpreting the logistic regression model, Inference for logistic regression, Logistic regression with categorical predictors, Multiple logistic regression.

Unit V: Building and Applying Logistic Regression Models: Strategies in model selection, Model checking, Conditional logistic regression and exact inference, Sample size and power of logistic regression.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Alan Agresti (2007). *An Introduction to Categorical Data Analysis*, 2nd ed., Wiley, New York.

Reference Books

1. Radhakrishna Rao. (2021). *Linear Statistical Inference and its Applications* (2nd ed.). Wiley-Interscience. ISBN: 0471218758.

2. Bergsma,W., Croon,M.A., & Hagenaars, J.A. (2009). *Marginal Models: For Dependent, Clustered, and Longitudinal Categorical Data*. Springer, New York.

3. David, W. Hosmer Jr, Stanley Lameshow. (1999): *Applied Survival Analysis.* John Wiley and son, INC.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the concept of probability distribution most often used for categorical data.
2. Identify and summaries categorical data into 2 × 2 and r × c contingency tables.
3. Know the use of generalized liner models and generalized estimating equations.
4. Understand the models for the binary response variables and to fit logistic regression.
5. Building and applying conditional logistic regression model.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	M	S	M	M
CO2	M	M	S	S	M	S	S	S	S	M
CO3	S	S	S	M	S	S	M	M	S	S
CO4	M	S	S	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-I	23PSTAE14-2: Population Studies	Credit	3
I Year		Hours/ Week	5
I Semester			

Pre-requisite
Basic statistical literacy.

Objectives of the Course

1. Students will become familiar with basic concepts and sources of data in Demography.
2. To comprehend the processes and events in Demography and their interactions.
3. To discuss the various factors affecting population growth and its proximate determinants.
4. To understand all the mathematical procedures that measure population change.
5. Their underlying factor helps in visualizing the future prospects of population growth.

Course Outline

Unit I: Population Studies – Concept, Definition, Nature and Significance - Components of Population Change : Fertility, Mortality, Migration and other Determinants - Development of Population Studies as a Discipline - Components of Demography: Population Size, Structure and Distribution.

Unit II: Introduction to Demography: Sources of Demographic data – Nature, Scope and importance of demography – relationship with other disciplines. Analysis of age distribution - percent distribution – percent change by age – graphical representation of age data – population pyramid – sex ratio – aging of population – measures of aging of population.

Unit III: Mortality and life tables: Crude and specific rates – infant mortality rate – standardized death rates – direct and indirect method of standardization. Life tables – constructions and uses – abridged life table – construction – Reed Merrell method – Greville's method – Chiang's method.

Unit IV: Fertility: Crude and specific rates – General fertility rate – Total fertility rate – Age specific fertility rate - Gross reproduction rate – Net reproduction rate – parity progression ratio - child women ratio – fertility differential – determinants of fertility.

Unit V: Population growth: Concept of stable and stationary population, measurement of population growth – arithmetic, geometric and exponential- population projection and estimation – different methods of projection.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Hinde, Andrew (1998): *Demographic Methods*, London: Edward Arnold.
2. Cox, P. (1959): *Demography*, 2nd ed, Cambridge University Press.

Reference Books

1. Keyfitz, (1985): *Applied Mathematical Demography*, 2nd ed, Springer-Verlag, New York.
2. Shrivastava, O.S. (1995): *Demography and Population Studies*, 2nd ed, Vikas Publishing house private Ltd.

Website and e-Learning Source

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the various sources of data in Demography and comprehend the basic concepts and definitions.
2. Interpret the definitions in terms of fertility, mortality, migration and construction of life table.
3. Analyze the Population Growth and fit the data using various models such as Arithmetic, Geometric, Exponential, Logistic.
4. Relate the components of population change-fertility, mortality and migration, causes and consequences of change in the population.
5. Explain the rates and ratios – Person years lived, Crude and specific rates.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	S	S
CO2	S	S	S	S	M	S	M	S	M	S
CO3	S	S	S	M	S	S	S	M	S	M
CO4	M	M	S	S	S	S	S	S	M	M
CO5	S	S	M	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-II	23PSTAE15-1: Bayesian Inference	Credit	3
I Year		Hours/ Week	5
I Semester			

Pre-requisite
Under graduate level probability.

Objectives of the Course
1. Enable the students to understand the basic ideas of Bayesian inference.
2. To achieve knowledge about the Bayes risk.
3. To provide necessary skills to evaluate the subjective probability.
4. To learn the method of Bayes estimators under various loss functions.
5. To understand confidence co-efficient of an interval by Bayesian.

Course Outline

Unit I: Statistical decision theory – loss functions – 0-1, absolute error, squared error and LINEX loss functions – risk function – minimax solution – prior distribution – Bayes risk – Bayes solution to decision problems.

Unit II: Subjective probability – its interpretation and evaluation - Subjective determination of prior distributions - Improper prior, non-informative prior, invariant prior, Jeffreys non informative prior and natural conjugate prior – family of distributions admitting natural conjugate prior.

Unit III: Point estimation – Bayes estimators under various loss functions- generalization to convex loss functions - Evaluation of the estimate in terms of posterior risk – comparison with frequentist methods.

Unit IV: Interval estimation – credible interval, highest posterior density region- Comparison of interpretation of the confidence co-efficient of an interval by Bayesian and frequentist methods – simple problems.

Unit V: Bayesian testing of statistical hypotheses – specification of the appropriate form of the prior distribution for Bayesian hypothesis testing problem – prior odds, posterior odds, Bayes factor and their computations to various hypotheses testing problems– specification of Bayes tests.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books
1. Bansal, A.K. (2007): *Bayesian Parametric Inference*, Narosa, New Delhi.

2. Berger, J.O. (1985): *Statistical Decision Theory and Bayesian Analysis*, 2nd ed, Springer, New York.

Reference Books

1. Bernardo, J.M. and Smith, A.F.M. (2000): *Bayesian Theory*, Wiley, New York.
2. Gelman, A. Carlin, J.B. Stern, H.B. and Rubin, D.B. (2013): *Bayesian Data Analysis*, 3rd ed, CRC press, London.
3. Ghosh, J.K. Delampady, M. and Samanta, T. (2010): *An Introduction to Bayesian Analysis: Theory and Methods*, Springer, New York.
4. Lee, P.M. (2012): *Bayesian Statistics – An introduction*,4th ed., Wiley, London.
5. Leonard, T. and J.S.J. Hsu. (1999): *Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers*, Cambridge University Press, London.
6. Robert, C.P. (1994): *The Bayesian Choice: A Decision-Theoretic Motivation*, 2nd ed., Springer, New York.
7. Robert, C.P. and Casella, G. (2004): *Monte Carlo Statistical Methods*, 2nd ed., Springer, New York.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. understand the knowledge on importance of the statistical decision theory.
2. interpret subjective probability.
3. explain the evaluation of the estimate in terms of posterior risk.
4. understand the comparison of interpretation of the confidence co-efficient of an interval by Bayesian and frequentist methods.
5. Understand the Bayesian testing of statistical hypotheses.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	M	S	M	M
CO2	S	S	S	S	M	M	M	S	M	M
CO3	S	S	S	M	S	S	M	S	S	S
CO4	S	M	S	S	S	S	S	S	M	S
CO5	S	S	S	S	S	S	S	S	S	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-II	23PSTAE15-2: Clinical Trials	Credit	3
I Year		Hours/ Week	5
I Semester			

Pre-requisite

A solid understanding of basic statistical concepts is essential for comprehending the design, analysis, and interpretation of clinical trials.

Objectives of the Course

1. Introduce students to the fundamental concepts and principles of clinical trials.
2. Provide an overview of the ethical and regulatory considerations governing clinical trials.
3. Familiarize students with the different phases of clinical trials and the associated study designs.
4. Develop students' understanding of statistical methods used in the analysis of clinical trial data.
5. Enhance students' knowledge of randomization, blinding and other design considerations.

Course Outline

Unit I: Introduction to Clinical Trials-Overview of clinical trials and their importance, Ethical considerations and regulatory framework, Phases of clinical trials - Statistical Principles in clinical trials: Basic statistical concepts and terminology, Types of data in clinical trials, Randomization and allocation methods, Sample size determination and power calculations.

Unit II: Study Designs: Parallel-group designs, Crossover designs, Factorial designs, Adaptive designs, Randomization and Masking, Simple randomization, Stratified randomization, Blocked randomization, Blinding and masking techniques.

Unit III: Treatment Comparisons: Comparing means, t-tests, ANOVA-Comparing proportions: Chi-square tests, Non-parametric methods.

Unit IV: Missing data and sensitivity analysis: Handling missing data. Intention-to-treat analysis, Sensitivity analysis techniques.

Unit V: Special Topics: Subgroup analysis and interaction testing, Meta-analysis of clinical trial data, Bayesian methods in clinical trials, Adaptive trial designs.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Machin, D (2004): *Text Book of Clinical Trials*, Wiley.
2. Sundar Rao, P.S.S, and Richard, J (2012): *Bio Statistics and Research Methods*, PHI.

Reference Books

1. Douglas G.Altman (1991): *Practical Statistics for Medical Research*, CRC.
2. Carol Redmond Theodore Colton, (2001): *Bio Statistics in Clinical Trials*, Wiley.
3. Shein-Chung Chow, Jen-Pei Liu, (2013): *Design and Analysis of Clinical Trials*, Wiley.
4. Alwi E. Lewis : *Bio Statistics*, East west Press.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Acquire a deep understanding of the principles, concepts, and methods used in the design of clinical trials.
2. Gain knowledge of the ethical considerations and regulatory guidelines governing clinical trials, including informed consent, participant protection, and data confidentiality.
3. Develop proficiency in the statistical analysis techniques commonly employed in clinical trials.
4. Learn about randomization methods and the importance of blinding in clinical trials to minimize bias and ensure the validity of study results.
5. Develop the skills to effectively communicate clinical trial findings to both scientific and non-scientific audiences.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	M	S	M	S	M	M
CO2	S	S	S	S	M	S	M	S	M	S
CO3	S	S	S	M	S	S	M	S	S	M
CO4	M	S	S	S	S	S	S	S	M	M
CO5	S	S	M	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-IV	23PSTAC21: Estimation Theory	Credit	5
I Year		Hours Per Week	6
II Semester			

Pre-requisite

Basic concepts of probability theory.

Objectives of the Course

1. To make the students to understand the basic concepts of the statistical estimation theory.
2. To study the properties of ideal estimators like unbaisedness, consistency, sufficiency, completeness.
3. To understand Cramer- Rao lower bound and Bhattacharya system of lower bounds.
4. To study the concepts of minimax estimation.
5. To educate various estimation methods like method of moments, method of maximum likelihood, interval estimate and Bayes estimate.

Course Outline

Unit I: Sufficient statistics, Neyman, Fisher Factorisation theorem, the existence and construction of minimal sufficient statistics, Minimal sufficient statistics and exponential family, sufficiency and completeness, sufficiency and invariance.

Unit II: Unbiased estimation: Minimum variance unbiased estimation, locally minimum variance unbiased estimators, Rao Blackwell theorem. Completeness- Lehmann Scheffe theorems, Necessary and sufficient condition for unbiased estimators.

Unit III: Cramer- Rao lower bound, Bhattacharya system of lower bounds in the one parameter regular case. Chapman-Robbins inequality.

Unit IV: Maximum likelihood estimation, computational routines, strong consistency of maximum likelihood estimators, Asymptotic Efficiency of maximum likelihood estimators, Best Asymptotically Normal estimators, Method of moments.

Unit V: Bayes and minimax estimation: The structure of Bayes rules, Bayes estimators for quadratic and convex loss functions, minimax estimation and interval estimation.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / applied survey techniques adopted in Economics and Statistics department of Tamil Nadu State Government. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Rohatgi, V.K. and Ehsanes Saleh, A.K.Md (2010): *An Introduction to Probability and Statistics*, John Wiley and Sons.
2. Rajagopalan, M and Dhanavanthan. P (2012): *Statistical Inference*, PHI Learning Private Limited, New Delhi.

Reference Books

1. Lehmann, E.L (1983): *Theory of Point Estimation*, John Wiley.
2. Gibbons (1971): *Non-Parametric Inference*, Tata McGraw Hill.
3. Zacks, S (1971): *The Theory of Statistical Inference*, John Wiley.
4. Rao, C.R (1973): *Linear Statistical Inference and its Applications*, Wiley Eastern, 2nd ed.
5. Ferguson, T.S. (1967): *Mathematical Statistics, A Decision Theoretic Approach*, Academic press, New York and London.
6. Lindley, D.V (1965): *Introduction to Probability and Statistics*, Part 2, Inference, Cambridge University Press.
7. Manoj Kumar Srivastava, Abdul Hamid Khan and Namita Srivatsava (2014): *Statistical Inference – Theory of Estimation.* PHI Learning Private Limited, Delhi.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. understand the consistency, sufficiency and unbiasedness.
2. understand the concepts and drive the uniformly minimum variance unbiased estimators.
3. derive the inequality including CR inequality, KCR inequality and Bhattacharya inequality.
4. estimate the parameter using method of moments, method of MLE, Interval estimation and shortest with confidence intervals.
5. learn the concepts and to apply simple numerical illustration for loss function, risk function and Bayes estimate.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	M	M
CO2	S	S	S	M	M	S	S	S	S	S
CO3	M	S	S	S	S	S	M	S	S	S
CO4	S	M	S	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-V	23PSTAC22: Measure and Probability Theory	Credit	5
I Year		Hours Per Week	6
II Semester			

Pre-requisite

Undergraduate level mathematics.

Objectives of the Course

1. To introduce measure theory in a rigorous way and explore some applications to probability theory.
2. This course provides mathematical background for the knowledge of probability theory extended from measure theoretical approach.
3. The students will be able to understand the basic concepts of the distribution function and random variables that help in understanding for estimation and testing problems in statistical inference.
4. To understand the concept and applications of Central limit theorems.
5. The fundamentals of this course will pave the way for further research.

Course Outline

Unit I: Measure Theory - Limits of sequence of sets, classes of sets – Field, Sigma Field and Monotone class, Measure and Measure Space – Measurable function.

Unit II: Lebesgue – Stieltjes measure, Measure integral and its properties, Dominated convergence theorem – Radon–Nikodymn theorem, almost everywhere convergence, convergence in measure and convergence in mean.

Unit III: Events, sample space, different approaches to probability, random variables and random vector, Distribution functions of random variables and random vector, Expectation and moments, basic, Markov, Chebyshev's, Holder's, Minkowski's and Jensen's inequalities.

Unit IV: Independence of sequence of events and random variables, conditional probability, conditional expectation, Characteristic functions and their properties, inversion formula, convergence of random variables, convergence in probability, almost surely, in the r^{th} mean and in distribution, their relationships, convergence of moments, Helly-Bray theorem, continuity theorem and convolution of distributions.

Unit V: Central limit theorem, statement of CLT, Lindeberg, Levy and Liapounov forms with proof and Lindeberg Feller's form examples. Khintchine weak law of large numbers, Kolmogorov inequality, strong law of large numbers.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Bhat, B.R. (2019). *Modern Probability Theory* (Revised 4th ed.). New Age International Publisher, New Delhi.
2. Burill, C.W (1972). *Measure, Integration and Probability*, McGraw Hill, New York.

Reference Books

1. Billingsley, P (2012): *Probability and Measure* (3rd ed.), Wiley, New York.
2. Parthasarthy, K.R (1977): *Introduction to Probability and Measure*, MacMillan Co.
3. Breiman, L. (1968): *Probability*, Addison Wesley.
4. Munroe, M.E. (1971): *Measure and Integration*, 2nd ed. Addison Wesley.
5. Halmos, P.R. (1974): *Measure Theory*, East-West.
6. De Barr, G. (1987): *Measure Theory and Integration*, Wiley Eastern.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Resolve problems that occur in the sequences of sets and classes of sets.
2. Provide critical thinking in integrals and their application to probability theory.
3. Evaluate, integrate and apply appropriate tools in probability and conditional probability.
4. Demonstrate the ability to apply basic methods in analyzing the convergence in probability and r^{th} mean and its distribution and characteristics functions.
5. Demonstrate critical thinking skills, such as problem solving using weak and strong law of large numbers and different forms of Central Limit Theorems.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	M	S	M	M
CO2	M	M	S	S	M	S	S	S	M	S
CO3	S	S	S	M	S	S	M	S	M	S
CO4	M	S	S	S	S	S	S	S	S	M
CO5	S	S	S	S	S	S	S	M	S	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-VI	23PSTAC23: Time Series Analysis	Credit	4
I Year		Hours Per Week	6
II Semester			

Pre-requisite

Undergraduate level time series modeling.

Objectives of the Course

1. Understanding of various components of time series and forecasting models.
2. Apply different methods for fitting time series models.
3. Understanding important concepts in forecasting and smoothing methods.
4. Gain knowledge in stationary and non-stationary nature of time series data.
5. Know the Description and properties of ARIMA models.

Course Outline

Unit I: Time Series – Introduction – components of time series – stationary and non-stationary time series - differencing method to convert non stationary series – concept of co integration.

Unit II: Standard statistical measures for Time Series analysis: Absolute measures – Mean absolute error, Mean error, Mean square error. Relative measures – Percentage error, Mean percentage error, Mean absolute percentage error.

Unit III: Smoothing methods – Single exponential smoothing. Double exponential smoothing (Holt method). Triple exponential smoothing (Holt-Winter's method).

Unit IV: Decomposition method: Additive and Multiplicative decomposition – Forecast and Confidence Intervals – Kruskal-Wallis test for seasonality - Moving average Forecasting – Spencer's and Henderson's moving averages (without derivation). Stationary and Non-stationary Time series- Auto correlation function (ACF) and Partial Auto correlation function (PACF)- Portmanteau tests: Ljung–Box test and Box–Pierce test.

Unit V: ARIMA models: Random model ARIMA (0,0,0), Non-Stationary Random model, ARIMA (0,1,0), Stationary Auto Regressive model of order one-ARIMA (1,0,0). Stationary Moving average model of order one-ARIMA (0,0,1)-A Simple Mixed model ARIMA (1,0,1), ARIMA (1,1,1)-Seasonal Time series ARIMA(p,d,q) (P, D,Q) with ARIMA (0,1,1)(0,1,1), ARCH and GARCH models: Description and properties of these models (Without proof).

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Cooray, T.M.J.A (2008): *Applied Time Series Analysis and Forecasting*, Narosa publishing house Pvt. Ltd.
2. Montgomery, D. C. and Johnson, L. A. (1977): *Forecasting and Time Series Analysis*. McGraw Hill.

Reference Books

1. Anderson, T. W. (2011): *The Statistical Analysis of Time Series*. John Wiley and Sons.
2. Chatfield, C. (1996): *The Analysis of Time Series: Theory and Practice* (5th ed.). Chapman and Hall.
3. Diggle, P.J. (1990): *Time Series: A Bio-Statistical Introduction*. Oxford University press.
4. Hamilton, J. (1994): *Time Series Analysis*. Princeton University Press.
5. Draper, N.R. and Smith, H. (2000): *Applied Regression Analysis*, 2nd ed., John Wiley & Sons.
6. Hannan, E.J. (1960). *Time Series Analysis*. Methuen, London.
7. Harvey, A.C. (1993).*Time Series Models*. MIT Press.
8. Spyros Makridakis, Steven C. Wheelwright and Victor E. McGee (2012): *Forecasting Methods and Applications* – 2nd ed., John Wiley & Sons.
9. Chattergee S. and Betram Price (1977): *Regression Analysis by Examples*, John Wiley & Sons.
10. George E.P. Box and Gwilym M. Jenkins (1976): *Time Series Analysis – Forecasting and Control*, Holdne – Day Inc.
11. Singh, Parashar and Singh (1997): *Econometrics and Mathematical Economics* 1st ed., S. Chand & Co, New Delhi.
12. Johnston J. (1984): *Econometric Methods*, 3rd Ed., McGraw Hill International Book Company, New Delhi.

Website and e-Learning Source

http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.mathpages.com

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Structuring the time series data based on seasonal and non-seasonal nature
2. Identifying the stationary of the time series
3. Modeling time series using exponential methods and Box-Jenkings model
4. Fitting time series model and evaluating goodness of fit
5. Understand the MA, AR, ARMA, ARIMA models.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	M	S	M	M
CO2	S	S	S	S	S	S	S	M	M	S
CO3	S	S	S	S	S	S	M	S	S	S
CO4	S	S	S	M	S	M	M	S	M	S
CO5	S	M	M	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-III	23PSTAE24-1: Actuarial Statistics	Credit	3
I Year		Hour/ Week	4
II Semester			

Pre-requisite
Under graduate level Business Mathematics.

Objectives of the Course

1. To have knowledge on life table, premium, profits and pension benefits.
2. To understand insurance and utility theory.
3. To know the concept of multiple life function.
4. To calculate premium and profit.
5. To acquire knowledge in pension benefits.

Course Outline

Unit I: Life tables and its relation with survival function- life table function at non integer age (fractional ages) – analytical laws of mortality - Gompertz and Makeham's law of mortality- select ultimate and aggregate mortality tables.

Unit II: Abridged life tables - construction of abridged life tables - methods by Read and Merrell, Greville's, Kings and JIA method. Utility theory - Insurance and utility theory.

Unit III: Models for individual claims and their sums - multiple life function - joint life status and last survival status.

Unit IV: Nature of reserve-prospective and retrospective reserves-fractional premiums and fractional durations- modified reserves- Continuous reserves - Surrender values and paid up policies - Industrial assurance - Children's deferred assurances-Joint life and last survivorship.

Unit V: Capital sums on retirement and death- widow's pensions – Sickness benefits – Benefits dependent on marriage.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Barcley G.W. (1970): *Techniques of Population Analysis*, Wiley, New York.
2. Borowiak, D.S. and Shapiro, A.F (2013): *Financial and Actuarial Statistics: An Introduction.*CRC Press, London.

Reference Books

1. Alistair Neill. (1977): *Life contingencies*. Heinemann Professional Publishing, Portsmouth.
2. Donald, D.W.A. (1970): *Compound Interest and Annuities-certain*. For The Institute of Actuaries and the Faculty of Actuaries at the University Press.
3. Hooker, P.F. Longley, L.H and Cook (1957): *Life and other contingencies*. Cambridge.
4. Hossack, I.B., Pollard, J.H. and Zehnwirth, B (1999): *Introductory Statistics with Applications in General Insurance*. Cambridge University Press, Cambridge.
5. Spurgeon, E.T. (2011): *Life Contingencies*. Cambridge University Press, Cambridge.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the concept of mortality and construction of life table.
2. Know the insurance policies and to compute the problems related to it.
3. Learn the models of individual claims.
4. Understand the nature of reverse and industrial assurance.
5. Learn the concepts related to pension funds.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	S	M	S	M	M
CO2	S	S	S	S	M	M	S	S	M	S
CO3	M	S	S	M	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S
CO5	S	S	M	S	M	S	S	S	M	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-III	23PSTAE24-2: Simulation Analysis	Credit	3
I Year		Hours/ Week	4
II Semester			

Pre-requisite

A strong foundation in probability theory and statistical analysis is crucial for simulation analysis. Knowledge of probability distributions, random variables.

Objectives of the Course

1. Understand the principles and concepts of simulation analysis
2. Acquire knowledge of various simulation techniques and methodologies
3. Apply statistical analysis techniques to simulation output
4. Utilize optimization methods in simulation analysis
5. Develop practical simulation skills using software tools.

Course Outline

Unit I: Monte Carlo Methods: Introduction to Monte Carlo simulation, Generation of random variables and random processes, Variance reduction techniques, Markov chain Monte Carlo (MCMC) methods.

Unit II: Computational Techniques: Random number generation, Pseudo-random number generators, Random variate generation, Bootstrap methods.

Unit III: Simulation Based Inference: Estimation and hypothesis testing, Confidence intervals and p-values, Bayesian inference using simulation, Nonparametric methods.

Unit IV: Applications: Simulation based optimization, Resampling methods, Hidden Markov models Spatial statistics.

Unit V: Advanced Topics: Sequential Monte Carlo methods, Rare event simulation, Importance sampling, Model selection and model averaging.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Christian, P. Robert and George Casella, (1999): *Monte Carlo Statistical Methods*, Springer.

2. Averill, M. Law and W. David Kelton (1991): *Simulation Modeling and Analysis*, McGraw-Hill, New York.

Reference Books

1. Reuven Y. Rubinstein and Dirk P. Kroese (2016): *Simulation and the Monte Carlo Method,* Print ISBN:9781118632161, John Wiley & Sons.
2. Sheldon M. Ross 2006: *Simulation,* 4th ed. Academic Press.
3. Efron, B and Tibshirani, R.J. (1994): *An Introduction to the Bootstrap,* Chapman and Hall.
4. Manuel D. Rossetti, (2015): *Simulation Modeling and Arena*, Wiley.
5. Christopher A. Chung, (2003): *Simulation Modeling Handbook*: A Practical Approach, CRC Press.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Develop a comprehensive understanding of the fundamental principles and concepts underlying simulation analysis.
2. Gain familiarity with a range of simulation techniques and methodologies used in modeling and analyzing complex systems.
3. Develop the skills to create effective simulation models and design appropriate experiments to analyze system behavior.
4. Learn how to apply optimization methods within the context of simulation analysis to optimize system performance or make informed decisions.
5. Acquire hands-on experience with simulation software tools and develop proficiency in utilizing them to construct and analyze simulation models.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	S	M	S	M	S
CO2	S	M	S	S	M	S	S	S	M	M
CO3	S	S	S	M	S	S	M	S	S	M
CO4	M	S	S	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-IV	23PSTAE25-1: Survival Analysis	Credit	3
I Year		Hours/ Week	4
II Semester			

Pre-requisite
Under graduate level probability distribution.

Objectives of the Course

1. Able to estimate the parameters of lifetime distributions.
2. Learn various statistical lifetime models.
3. Know the concepts of increasing failure rate(IFR) and decreasing failure rate (DFR).
4. Understand the proportional hazards (PH) model with one and several covariates.
5. To improve the theoretical knowledge about risk model for parametric and non-parametric set up.

Course Outline

Unit I: Introduction to survival analysis- terminology and functions of survival analysis-goals- Basic data layout- Censoring – Different types of censoring- Parametric survival models based on basic life time distributions- Exponential, Weibull, Gamma and Log-logistic.

Unit II: Life tables, failure rate, mean residual life and their elementary properties. Concept of ageing, Types of ageing classes and their properties and relationship between them-Bathtub Failure rate, Concept of Inverse Hazard rate.

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

Unit IV: Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi- parametric regression for failure rate, Cox's proportional hazards(PH) model with one and several covariates and estimation problems in Cox's PH Model. Rank test for the regression coefficients.

Unit V: Introduction to Competing risks analysis and estimation problems in competing risk model for parametric and non- parametric semi parametric set up. Ideas of Multiple decrement life table and its applications.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Miller, R.G. (1981): *Survival analysis*, John Wiley.
2. Cox, D.R. and Oakes, D. (1984): *Analysis of Survival Data*, Chapman and Hall, New York.
3. Lee, E.T. and Wang, J.W. (2013). *Statistical Methods for Survival Data Analysis* (4th ed.).Wiley, New York.

Reference Books

1. Kleinbaum, D.G., & Klein, M.(2012): *Survival Analysis: A Self-LearningText* (3rd ed.). Springer Verlag, JohnWiley & Sons, New York.
2. Klein, J.P, & Moeschberger, M.L.(2003): *Survival analysis: Techniques for Censored and Truncated data*(2nd ed.).Springer– Verlag, New York.
3. Daniel, W.W.(2013): *Bio Statistics: Basic Concepts and Methodology for the Health Sciences* (10th ed.).
4. Gross, A.J. and Clark, V.A. (1975): *Survival distribution: Reliability Applications in the Biomedical Sciences*, John Wiley and Sons.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Expertise with various statistical lifetime models.
2. Understand the concept of lifetime distribution.
3. Understand the survival analysis.
4. Estimate the survival function under the assumptions.
5. Find the Hazard rate and functions.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	M	S
CO2	S	S	S	S	M	S	S	S	M	M
CO3	S	S	S	M	S	M	M	S	S	S
CO4	M	S	M	S	S	S	S	S	M	M
CO5	S	S	S	S	M	S	S	S	S	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-IV	23PSTAE25-2: Econometrics	Credit	3
I Year		Hours Per Week	4
II Semester			

Pre-requisite
Under graduate level Calculus, Mathematical Statistics and Linear Algebra.

Objectives of the Course

1. To study the various areas in production and demand.
2. To study auto correlation and economical forecasting.
3. To understand the concepts of estimators.
4. To study about simultaneous equations model.
5. To learn the concept of K-class estimators.

Course Outline

Unit I: Nature and scope of Econometrics - Illustrative examples Production and cost analysis - Theory and analysis of consumer demand specification - Estimation of demand function-Price and income elasticity of demand – Price elasticity's of supply - Torquivists model of demand for inferior goods, models building bias in construction of models.

Unit II: Single equation linear model: static case – Ordinary least square model and generalized least squares model: Introduction - estimation and prediction – Problem of multi collinearity and heteroscedasticity - Causes, consequences and solutions of estimation.

Unit III: Autocorrelation: Causes, consequences and testing for auto-correlated disturbances- Autoregressive series of order 1 (AR(1))- Lagged variables and distributed log method- Errors in variable models and instrumental variables. Economical forecasting: long term and short term.

Unit IV: Simultaneous equation model- Concept, structure and types –Identification problem with restrictions on variance and covariance – rank and order conditions of identifiability – Methods of estimation – Indirect least square method, two stage least squares method of estimation and estimation of limited information maximum likelihood (LIML).

Unit V: K-Class estimators – Full information Estimators – Full Information Maximum Likelihood (FIML)- Three Stage Least Square Estimators (3-SLS) and its properties – comparison of various estimation methods.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Johnston, J., & DiNardo, J. (1997). *Econometric Methods.* Mc Graw-Hill.

Reference Books

1. Castle, J and Shephard, N. (2009): *The Methodology and Practice of Econometrics*. Oxford University Press, London.
2. Draper N. R., and Smith. H. (1981): *Applied Regression Analysis*. John Wiley & Sons.
3. Goldberger, A.S. (1964): *Econometrics theory*. Wiley, New York.
4. Gujarati, D.N., Dawn C Porter and Sangeetha Kunasekar. (2016): *Basic Econometrics* (5th ed.). McGraw Hill Publisher, New York.
5. Kelejion, H.H., and Oates,W.E. (1988): *Introduction to Econometrics. Principles and Applications.* Harper and Row, New York.
6. Maddala,G.S., and Kajal Lagari. (2009): *Introduction to Econometrics*. Wiley, New York.
7. Madnani, G.M.K. (2008): *Introduction to Econometrics: Principles and Applications.* Oxford and IBH, New Delhi.
8. Wooldridge, J. (2012): *Introduction Econometrics: A Modern Approach*. Cengage Learning, New Delhi

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the various areas in econometrics and its model.
2. Learn linear model and problem of multi collinearity and heteroscedasticity.
3. Understand the concept of autocorrelation and economical forecasting.
4. Knowledge on estimation and LIML.
5. Understand the K-class estimators with its properties.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	M	M
CO2	S	S	S	S	M	S	M	S	M	S
CO3	S	S	S	S	S	S	S	S	S	M
CO4	S	M	S	S	S	S	S	S	M	M
CO5	S	S	S	M	M	S	S	S	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Skill Enhancement course (SEC)-I	23PSTAS26: Statistics Practical-I (Practical) (Using R)	Credit	2		
I Year		Hours Per Week	L	T	P
II Semester			-	-	4

Pre-requisite

Under graduate level mathematics and elementary problems on probability theory, sampling methods and time series analysis.

Objectives of the Course

1. To gain knowledge on statistical computations.
2. To present the theory and techniques of sample surveys with their applications in different types of problems.
3. How best to estimate the value of the parameters.
4. To provide a measure of the confidence in the estimate.
5. To understand the applications of time series analysis.

Course Outline

Sampling Theory

- ✧ Simple Random Sampling Methods of Drawing Sample.
- ✧ Calculation of Sample Size.
- ✧ Estimation of the Population Total.
- ✧ Mean and Variance of the Estimates with SRSWR and SRSWOR.
- ✧ Horvitz-Thompson Ordered Estimator.
- ✧ Des Raj's Ordered Estimator Murthy's Unordered Estimator.
- ✧ Linear and Circular Systematic Sampling.
- ✧ Stratified Random Sampling.
- ✧ Estimation of Mean, Variances under Stratified Random Sampling.
- ✧ Estimation of Proportion under SRSWOR.
- ✧ Ratio Estimators (for Stratified Sampling- Combined and Separate Estimates).
- ✧ Regression Estimator.
- ✧ Cluster Sampling (Cluster of Equal Sizes).

I. Estimation Theory

- ➢ Unbiased Estimator
- ➢ Maximum Likelihood Estimation (MLE).
- ➢ MLE through the method of approximation.
- ➢ MLE for truncated distribution.
- ➢ MLE by the method of scoring.
- ➢ MLE for the method of minimum Chi square.
- ➢ Method of Least Squares.
- ➢ Confidence Interval for mean, difference of mean, variance and ratio of variances.

II. Time Series Analysis

- ➢ Measurement of Trend
- ➢ Curve Fitting
- ➢ Exponential smoothing

- Stationary and Non Stationary Time Series
- Auto Correlation Function
- ARIMA Models.

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Explain the role of sampling in industrial problems.
2. Solving problems in unbiased estimator.
3. Estimate the values of the parameters.
4. Familiarize in drawing graphs of time series data.
5. Gain the practical knowledge on time series model.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	M	S	M	M
CO2	S	S	S	S	M	S	S	S	S	S
CO3	S	S	S	M	S	S	M	S	S	M
CO4	M	S	M	S	M	S	S	S	M	M
CO5	S	S	S	S	M	S	M	S	S	M

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-VII	23PSTAC31: Testing of Statistical Hypothesis	Credit	5
II Year		Hours/ Week	6
III Semester			

Pre-requisite

Basic knowledge in probability theory.

Objectives of the Course

1. To get theoretical knowledge in statistical testing procedure.
2. To provide knowledge about most powerful test and how to build it.
3. To understand concepts unbiasedness for hypotheses.
4. Testing, invariance, likelihood ratio tests and SPRT test.
5. To develop analytical thinking in statistical testing of hypothesis.

Course Outline

Unit I: Uniformly most powerful tests, the Neyman-Pearson fundamental Lemma, Distributionswith monotone likelihood ratio Problems**.**

Unit II: Generalization of the fundamental lemma, two sided hypotheses, testing the mean andvariance of a normal distribution.

Unit III: Unbiasedness for hypotheses testing, similarly and completeness, UMP unbiased tests for multi parameter exponential families, comparing two Poisson or Binomial populations, testingthe parameters of a normal distribution (unbiased tests), comparing the mean and variance of twonormal distributions.

Unit IV: Symmetry and invariance, maximal invariance, most powerful invariant tests.

Unit V: SPRT procedures, likelihood ratio tests, locally most powerful tests, the concept of confidence sets, non-parametric tests.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. V.K.Rohatgi et al. (2002): An introduction to probability and statistics, John Wiley.
2. Lehmann,E.L.(1986): Testing of statistical hypothesis, John Wiley.

Reference Books

1. Ferguson, T.S. (1967): Mathematical statistics, A decision theoretic approach, Academic press.
2. Rao, C.R. (1973): Linear statistical inference and its applications, Wiley Eastern, 2nd ed.

3. Gibbons, J.D. (1971): Non-parametric Statistical Inference, McGraw Hill.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. To do Most Powerful test for randomized and nonrandomized test.
2. To understand and classify unbiasedness and invariance concepts in testing.
3. To understand theory of LR and SPRT testing and able to solve problems on it.
4. To do numerical problems and able to get critical thinking to solve real life problems
5. To create suitable statistical hypothesis and identify its testing procedure for real life problems.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-VIII	23PSTAC32: MULTIVARIATE STATISTICAL ANALYSIS	Credit	5
II Year		Hours/ Week	6
III Semester			

Pre-requisite

Univariate, Multivariate distribution theory and linear Algebra.

Objectives of the Course

1. To impart basic theoretical knowledge about multivariate normal distribution, its properties to deal with multi-dimension data. To derive inference based on multi-variate statistical analysis concerning mean vector and covariance matrix.
2. To provide requisite knowledge to handle multi-dimensional data with regard todimensionality reduction using principal component and factor analysis. To imbibe skills to classify and assign a new item/object to any of the two or more populations using discrimination and classification.
3. To instruct theoretical knowledge to group variables or items that belong to multi-dimensional data using cluster algorithms

Course Outline

Unit I: Multivariate normal distribution and Its properties. Maximum likelihood estimators ofparameters, Distribution of sample mean vector, Sample dispersion matrix.

Unit II: Partial and multiple correlation coefficients- Null distribution - Application in testing. Null distribution of Hotelling's T^2 statistics. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population.

Unit III: Classification and discrimination procedures for discrimination between two multivariate normal populations – Linear discriminant function, Mahalanobis distance, tests associated with discriminant functions, probabilities of misclassification and their estimation, classification into more than two multivariate normal populations.

Unit IV: Principal component analysis, Canonical variables and canonical correlation, clustering- similarity measures- hierarchical algorithms- Single linkage, Non-hierarchical clustering.

Unit V: Contingency tables, Correspondence analysis for two dimension contingency table.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved. (To be discussed during the Tutorial hour)

Skills Acquired From This Course

Knowledge, problem solving, analytical ability, professional competency, professional communication and transferrable skill.

Recommended Text Books

1. Anderson, T.W. (1983): An Introduction to Multivariate Statistical Analysis. 2nd ed. Wiley.
2. Johnson,R. & Wichern (2008): Applied Multivariate Statistical Analysis, Pearson, 6th ed.

Reference Books

1. Brain S. Everitt and Graham Dunn (2001): Applied Multivariate Data Analysis, 2nd ed. (chap 4).
2. Neil H. Timm (2002): Applied Multivariate Analysis. Springer-Verlag.
3. Dallas E.Johnson (1998) :Applied Multivariate Methods For Data Analysts-DuxburyPress.
4. William R Dillon and Mathew Goldstein (1984): Multivariate Analysis Methods AndApplications, John Weily.

Website and e-Learning Source

e-books, tutorials on MOOC/SWAYAM courses on the subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. explain and interpret the importance of data that comes from high dimensional setupusing appropriate properties.
2. draw inference based on multi-variate statistical analysis concerning mean vectorand covariance matrix.
3. reduce dimensions and identify factors from multi-dimensional data using principalcomponent and factor analysis respectively.
4. classify and assign a new item/object to any of the two or more populations usingdiscrimination and classification.
5. group variables or items that belongs to multi-dimensional data using clusteralgorithms.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-IX	23PSTAC33: STATISTICAL QUALITY CONTROL	Credit	5
II Year		Hours/ Week	6
III Semester			

Pre-requisite

An introductory course in Statistics and familiarity with commonly used distributions.

Objectives of theCourse

1. To enhance the knowledge of statistical applications in industries.
2. To know the concept of various control charts.
3. To study the applications of CUSUM charts in industrial problems.
4. To have knowledge on sampling plans in industrial applications.
5. To acquiring knowledge on sampling plans.

Course Outline

Unit I: Statistical Quality Control and Control Charts

Meaning and scope of SQC - Causes of Quality variation - Statistical Basis for Control Charts - Choice of Control Limits - Sample size and Sampling Frequency - Rational subgroups – Specification - Tolerance and Warning Limits - Construction and operations of X bar, R and σ charts - np, p, c and u Charts. ***[Contents as in Chapters 4 and 5 of text book-1]***

Unit II: Cumulative Sum (CUSUM) Control Charts

CUSUM control chart - Basic Principles and Design of CUSUM charts - Concept of V-mask - One- and Two-Sided Decision Procedures – Moving Average and Geometric Moving Average Control Chart - Sloping Control Charts. ***[Contents as in Chapter 7 of text book-1]***

Unit III: Acceptance Sampling Plans

Acceptance Sampling Plans - Rectifying Inspection - Sampling Inspection by Attributes, Concept of OC, ASN, ATI, AOQ functions of sampling plans - AQL, LTPD, Producer's Risk and Consumer's Risk on OC curve - Operation and Use of Single, Double and Multiple Sampling Plans.

[Contents as in Chapter 13 of text book-1]

Unit IV: Continuous Sampling Plans

Sampling Inspection by Variables - known and unknown sigma, Variable sampling plan, merits and demerits of variable sampling plan, derivation of OC curve. ***[Contents as in Chapter 14 of text book-1]***

Unit V: Determination of parameters of the plan. Continuous Sampling Plans (CSP) by attributes, CSP-1, CSP -2 and CSP-3. Concept of AOQL in CSPs - Indian Standards ISO 2000 (concepts only).

[Contents as in Chapter 14 of text book-1]

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this Course

Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill.

Recommended Text Books

1. Douglas C. Montgomery. (2005). *Introduction to Statistical Quality Control* (3rd ed.). John Wiley & Sons, New York.
2. Duncan A.J. (1959). *Quality control and Industrial Management.* (Richard D. Irwin Inc. USA)

Reference Books

1. Bain, L. & Engelhardt, M. (1991). *Statistical Analysis of Reliability and Life Testing Models*. Marcel-Dekker, New York, NY, USA.
2. Biswas, S. (1996). *Statistics of Quality control, Sampling Inspection and Reliability*. New Age India International.
3. Burr, I.W. (1953). *Engineering Statistics and Quality Control.* McGraw Hill.
4. Leaven Worth, R.S. (1964). *Statistical Quality Control.* Mc Graw Hill.
5. Mahajan, M. (1998). *Statistical Quality Control*. Dhanpat Rao & Co, New Delhi.
6. Schilling, E.G. (1982). *Advances in acceptance sampling*. ASQC Publications, New York.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Draw and obtaining results of various control charts.
2. Study the Cusum, V-mask and moving average control charts.
3. Understand the concepts of acceptance sampling plans and their functions.
4. Apply the various sampling inspections in real life situations.
5. Understand the various concepts of sampling plans and their applications.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	M
CO2	M	S	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core X **Practical-II**	**23PSTAP34: STATISTICS PRACTICAL-II**	**Credit**	**4**
II Year		**Hours/ Week**	**6**
III Semester			

Testing of Hypotheses

- ✧ Critical regions and power curves.
- ✧ Testing hypothesis on the parameters of the following distributions: Binomial distribution, Normal distribution and Exponential Distribution.
- ✧ Simple Hypothesis, One sided and two sided alternatives.
- ✧ Non-Parametric Tests:
  - o Sign Test, Kolmogorov-Smirnov Test
  - o Median Test
  - o Wald-Wolfowitz Run Test
  - o Mann-Whitney U-Test and Test for Randomness.
- ✧ Sequential Probability Ratio Test for simple hypotheses
- ✧ Most powerful test Estimation of Power and Size
- ✧ Uniformly MP test - Estimation of Power and Size.

Multivariate Analysis

- ✧ Estimation of Mean Vector and Covariance Matrix.
- ✧ Test for the Mean Vector when Covariance Matrix is known.
- ✧ Test for Equality of Mean vector.
- ✧ Test for the Mean Vector when Covariance Matrix is unknown.
- ✧ Test for Covariance Matrix.
- ✧ Test for Equality of Covariance Matrices.

Statistical Quality Control

- ✧ Control Chart for $\bar{X}$ and R
- ✧ Control Chart for $\bar{X}$ and S
- ✧ NP – Control Chart
- ✧ P – Chart
- ✧ C – Chart
- ✧ U – Chart
- ✧ Single sampling plan – OC, ASN, ATI and AOQ.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the concept of testing statistical hypotheses related to real life problems.
2. Apply the multivariate statistical tests.
3. Know the applications of multivariate estimations.
4. Know the applications of statistical Quality Control.
5. Solve the problems using real life data.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-V	**23PSTAE35-1: Operations Research**	**Credit**	**3**
II Year		**Hours/ Week**	**3**
III Semester			

Pre-requisite

Linear Programming problem–Simplex and Dual Simplex methods. Transportation and assignment problems and their solution

Objectives of theCourse

To build strong theoretical foundation of various optimization techniques in operations research that makes use of statistical concepts abundantly.

Course Outline

Unit I: Sensitivity Analysis – Variation in cost vector 'c' – Variation in the requirement vector 'b' – Addition and Deletion of single variable – Addition and Deletion of single constraint.

Unit II: Parametric linear programming – parameterization of the cost vector 'c' – Parameterization of requirement vector 'b' – All integer programming problem – Mixed integer programming problem – Branch and Bound techniques.

Unit III: Non-linear programming problem (NLPP) – Kuhn-Tucker condition – Wolfe's and Beale's algorithms for solving quadratic programming problem.

Unit IV: Inventory models – Structure of Inventory system – General deterministic problem for one item, one level – Inventory models with and without shortage – Multi item deterministic problem – one level model with one break.

Unit V: Forecasting of demand-Forecasting methods, Moving average method for forecasting-Exponential smoothed average method. Determination of safety stock.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this Course

Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill.

Recommended Text Books

1. Prem Kumar Gupta & Hira, D.S. (2010). *Problems in Operations Research*. Sultan Chand & Co. Limited, New Delhi.
2. Kanti Swarup, Gupta, P.K., & Man Mohan (2007). *Operations Research.* Sultan Chand & Sons, New Delhi.

Reference Books

1. Sharma, J.K.(2013). *Operation Research: Problems and Solutions* (5th ed.). Macmillan India, New Delhi.
2. Hadley,G. (1963). *Linear Programming*. AddisonWesley.
3. Hillier,F.S.& Lieberman,G.J.(2005). *Introduction to Operations*(9th ed.) Mc Graw Hill, New York.
4. Kambo, N.S. (1991). *Mathematical Programming techniques.* Affiliated East-west Press Pvt Ltd.
5. Rao, S.S. (2004). *Engineering Optimization.* New Age International (P) Ltd, New Delhi.
6. Sharma,S.D.(2010).*Operations Research*. Kedarnath Ramnath, Meerut.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand application of Statistical and Mathematical concepts in Operations Research.
2. Identify suitable method for solving optimization problems.
3. Understand the different algorithms for solving quadratic programming problem.
4. Apply Inventory models with and without shortage
5. Solve the Forecasting methods using inventory models.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	M	S	M
CO2	M	S	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Elective-V	**23PSTAE35-2: DATABASE MANAGEMENT SYSTEM**	**Credit**	**3**
II Year		**Hours/ Week**	**3**
III Semester			

Pre-requisite

Fundamental computer knowledge that includes concepts of computer architecture and storage.

Objectives of theCourse

1. To understand the nature and characteristics of database
2. To gain the knowledge of tables and relationships
3. To know the difference between data and information
4. To learn functions of database management system
5. Learning about PL/SQL

Course Outline

Unit I: Database basics- History of database, Data and information, need for database file based data management system database system database characteristics advantages of database limitations of database.

Unit II: Hierarchical database model, network data model, relational database model, object oriented data model, object relational data model, three-level architecture of a database, data independents.

Unit III: Relational database management system-difference between RDBMS and DBMS, features, advantages and disadvantages of RDBMS, RDBMS terminologies, keys in database, Relational algebra.

Unit IV: Structured query language (SQL): select statements- CODD'S 12 rules of relational database- database development life cycle: database design, implementation of database, testing and evaluation, operation and maintenance of database system.

Unit V: Introduction to PL/SQL: variables and constants, Data types, control statements, case statements, Loop, Continue statement, Goto statement, function, Syntax and examples, Trigger and Examples.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this Course

Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill.

Recommended Text Books

1. Jagdish Chandra Patni, Hitesh Kumar Sharma, Ravi Tomar and Avita Katal (2022): *Database Management System- An Evolutionary Approach,* CRC Press.
2. Abraham Silberschatz, Henry F. Korth, and S. Sudarshan. *Database System Concepts.*
3. Raghu Ramakrishnan and Johannes Gehrke. *Database Management Systems,* TATA McGrawHill 3rd Edition.

Reference Books

1. Elmasri Navathe Pearson Education. *Fundamentals of Database Systems.*
2. C.J. Date, A.Kannan, S.Swami Nadhan, *An Introduction to Database systems* Pearson, 8th Edition.
3. Ramez Elmasri and Shamkant B. Navathe. *Fundamentals of Database Systems,* Pearson Education.
4. Hector Garcia-Molina, Jeffrey D. Ullman, and Jennifer Widom. *Database Systems: The Complete Book.*
5. Jeffrey A. Hoffer, Ramesh Venkataraman, and Heikki Topi. *Modern Database Management*

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	S	S	M	S	M
CO2	S	M	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	S	M	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	S	M	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Skill Enhancement Course (SEC)-II	**23PSTAS36: Computational Statistics Using Python**	**Credit**	**2**
II Year		**Hours/ Week**	**3**
III Semester			

Pre-requisite

Basic computer knowledge

Objectives of theCourse

1. To enable the students to learn basic python operators.
2. To acquire the knowledge on data handling and string in python.
3. To know the file handling commands.
4. To know the application of pandas.
5. To familiarize the students in solving time series problems using python.

Course Outline

Unit I: Introduction to Python and Data Manipulation: Introduction to Python programming- Basic data types and data structures in Python- Data input and output- Data manipulation with NumPy and pandas. Data Visualization with Matplotlib and Seaborn: Introduction to data visualization- Using Matplotlib for creating plots and charts- Exploring Seaborn for advanced data visualization.

Unit II: Probability and Distributions: Probability concepts and rules- Discrete and continuous probability distributions- Generating random samples from distributions using NumPy. **Descriptive Statistics and Exploratory Data Analysis:** Summary statistics (mean, median, standard deviation, etc.)- Data exploration techniques- Outlier detection and handling using Python.

Unit III: Linear Regression in Python: Simple linear regression- Multiple linear regression- Model diagnostics and assumptions in regression analysis - Correlation Analysis using Python

Unit IV: Test of Significance with Python: Hypothesis testing based on t, chi-square and F distributions with examples in Python.

Unit V: Time Series Analysis using Python: Stationary and non-stationary time series- Autoregressive Integrated Moving Average (ARIMA) models.

Extended ProfessionalComponent (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this Course

Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill.

Recommended Text Books

1. Jake Vander Plas (2016). *Python Data Science Handbook: Essential Tools for Working with Data* (1st ed.). O'Reilly Media, Inc., USA.
2. Jeeva Jose & Sojan Lal, P. (2016). *Introduction to Computing and Problem Solving with Python*. Khanna Book Publising Co. (P) Ltd.

3. WesMcKinney (2013). *Python for Data Analysis* (2nd ed.). O'Reilly Media, Inc., USA.

Reference Books

1. Guttag, J.V. (2016). *Introduction to computation and programming using Python*. (2nd ed.). MIT Press.
2. Kamthane, A. N., & Kamthane, A.A. (2017). *Programming and Problem Solving with Python.* McGraw Hill Education.
3. Kulkarni (2017). *Problem Solving and Python Programming* (1st ed.). Yes Dee Publishing Pvt Ltd.
4. Liang, Y. D. (2013). *Introduction to Programming using Python*. Pearson Education.
5. Taneja, S.& Kumar, N. (2018). *Python Programming- A modular Approach.* Pearson Education India.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

1. Gain ability to apply knowledge of python to the real life situation
2. Build up programming , analytical and logical thinking abilities
3.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	S	S	M	S	M
CO2	S	M	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	S	M	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	S	M	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

II Year		**Credit: 2**
III Semester	**23PSTAI37: SUMMER INTERNSHIP**	**Hours/Week: -**

(Refer to the regulations)

Core-XI	**23PSTAC41: DESIGN OF EXPERIMENTS**	**Credit**	**5**
II Year		**Hours/ Week**	**6**
IV Semester			

Pre-requisite

Matrix algebra and Linear Models.

Objectives of theCourse

1. To get theoretical knowledge in Statistical Design of Experiments and analysis of variance.
2. To build strong theoretical foundation in orthogonal Latin squares, Hyper Graeco Latin squares, factrorial and fractional factorial experiments, PIBD, inter and intra blocks, split plot, analysis covariance, response surface methodology.
3. To develop analytical thinking in problem solving skills.

Course Outline

Unit I: Review of basic designs; Orthogonal Latin squares, Hyper Graeco Latin squares – analysis of variance – multiple comparisons – multiple range tests - Missing plot technique.

Unit II: General factorial experiments, study of 2 and 3 factorial experiments in randomized blocks; complete and partial confounding; Fractional designs for symmetric factorials; basic idea of asymmetric factorials.

Unit III: General block design and its information matrix (C), criteria for connectedness, balanced and orthogonality; BIBD – recovery of inter block information; PBIBD(2).- Association scheme, Intra block analysis, Lattice Design –analysis; Youden design – intra block analysis.

Unit IV: Nested and split plot designs – Two stage nested designs, split plot designs, split plot designs, strip-split designs, Analysis of covariance with one, two covariates; clinical trials.

Unit V: Response surface methodology - first order and second order rotatable designs, applications.

Extended Professional Component (is a partof internal component only, Not to be included in theExternal Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC / others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this course

Knowledge, Problem Solving, Analyticalability, Professional Competency, Professional Communication and Transferrable Skill**.**

Recommended Text

1. Das, M.N. and Giri, N. (1979): Design and analysis of experiments, Wiley Eastern.
2. John, P.W.M. (1971) : Statistical design and analysis of experiments, Macmillan.

Reference Books

1. Montgomery, C.D. (2001): Design and analysis of experiments, John Wiley, NewYork.
2. Robert, O., Kuelhl (2000): Design of experiments. Statistical principles of researchdesign and analysis, Duxbury.
3. Federer, W.T. (1963): Experimental design; Theory and application, Oxford & IBHpublishing Co.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. To understand analysis of variance and experimental designs.
2. To have strong theoretical knowledge in Orthogonal Latin squares, Hyper Graeco Latin squares, factorial and fractional factorial experiments, PIBD, inter and intra blocks, split plot, analysis covariance.
3. To understand clinical trial concepts and Response surface methodology.
4. To do numerical problems and able to get critical thinking to solve problems.
5. To choose suitable experiment and do it for real life problems.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	S	S	M
CO2	S	S	M	S	M	S	S	S	M	M
CO3	S	S	S	M	S	S	S	S	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	S	S	M	M	S	S	S	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core-XII	**23PSTAC42: STOCHASTIC PROCESSES**	**Credit**	**5**
II Year		**Hours/ Week**	**6**
IV Semester			

Pre-requisite

Basic knowledge in Probability theory and Distribution theory

Objectives of theCourse

1. To expose the basic concepts of the theory of stochastic processes and develops themathematical theory of random processes.

2. It provides the fundamentals and advanced concepts of probability theory and helpthem appreciate and understand the application of the mathematical tool.

3. To describe the advanced topics related to continuous and discrete time random process

4. To understand the Renewal theory

5. To know the concepts and applications of queuing theory

Course Outline

Unit I: Definition of Stochastic process – Specification of Stochastic Processes. Stationary Processes – Second order process, Stationarity, Gaussian processes. Martingales: Definition and properties. Martingales in discrete time – Super martingales and sub martingales - Continuous Parameter Martingales- Martingale convergence theorem and its applications.

Unit II: Markov chains – Definitions and examples. Higher order transition probabilities: Chapman – Kolmogrov equation. Classification of States and Chains – Determination of Higher order Transition Probabilities -Aperiodic Chain: Limiting Behaviour. Stability of a Markov system.

Unit III: Poisson process – Poisson process and related distributions. Pure Birth Process – Birth and Death process – Simple examples. Branching process – properties of generating function of branching process – Probability of extinction – fundamental theorem of branching process.

Unit IV: Renewal theory - Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes.

Unit V: Queuing model M/M/1: Steady State Behaviour - Steady State Solution, Waiting time distribution. Queueing Model M/M/S - Steady State Solution, Waiting time distributions – simple problem.

Extended Professional Component (It is only a part of internal component. Not to be included in the External Examination question paper)

Questions related to the above topics, from various competitive examinations UPSC / TRB / NET / UGC – CSIR / GATE / TNPSC /others to be solved (To be discussed during the Tutorial hour)

Skills acquired from this Course

Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill.

Recommended Text Books

1. Medhi, J. (1984): Stochastic Processes, New Age International Publishing Limited, New Delhi. (Reprint 2002).
2. Karlin, S. and Taylor H.M. (1996): First Course in Stochastic Process, Academic Press.

Reference Books

1. Prabhu. N.U. (1965) : Stochastic Process, Macmillan, New York.

2. Ross, S.M (1996): Stochastic Processes, 2nd Edition, John Wiley & Sons, New Delhi.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. To equip their knowledge with theoretical and practical skills which are necessary for the analysis of stochastic dynamical system in economic, financial mathematics,engineering, business and other fields.
2. To attain knowledge about stochastic process in the time domain such as Markov processes with a discrete state space, including Markov chains, Poisson processes andbirth and death processes.
3. To demonstrate the specific applications to Poisson and Gaussian processes.
4. To carry out derivations involving conditional probability distributions and conditionalexpectations.
5. To define basic concepts from the theory of Markov chains and present proofs for the most important theorems.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Core Project	**23PSTAD43: Project with Viva-Voce**	**Credit**	**7**
II Year		**Hours Per Week**	**10**
IV Semester			

Course objectives

To enable students to utilize the theoretical knowledge gained in the core papers and to develop computational and technical skills for real life applications by collecting primary / secondary data and performing analyses and submitting their findings in the form of dissertation / project.

Course Outline

All the admitted candidates shall have to carryout a project work during the fourth semester under the supervision of the faculty of the Department of Statistics in the College. The core project shall be individual. Candidates shall have to submit three copies of the report of the project work at the end of the fourth semester at least two weeks before the last working day and shall have to appear for a Viva-Voce examination. The reports hall be evaluated and Viva-Voce examination shall be conducted jointly by an External Examiner and the Project Guide. The maximum marks for the project report and Viva–Voce examination shall be fixed as 100, which is split with the following components:

(Refer to the regulation for additional information)

Elective - IV **Core Practical-III**	**23PSTAE44: Statistics Practical-III***	**Credit**	**3**
II Year		**Hours/ Week**	**4**
IV Semester			

Course objectives

1. To enable students to solve problems related to design of experiment.
2. To solve the real-life problems related to stochastic processes.

Design of Experiments

- ✧ Completely Randomized Design.
- ✧ Randomized Block Design.
- ✧ Latin Square Design.
- ✧ Missing Plot Analysis in CRD, RBD and LSD.
- ✧ 2^2- Factorial Experiment.
- ✧ 2^3- Factorial Experiment.
- ✧ 2^3 - Factorial experiment with complete confounding.
- ✧ 2^3 - Factorial experiment with partial confounding.

Stochastic Processes

- ✧ Estimation –TPM.
- ✧ Stationary Probability.
- ✧ M/M/s Queuing models.
- ✧ Steady State Solution
- ✧ Waiting time distributions.

* Evaluation is to be done both for theory (15 marks) and practical (60 marks) components separately by the examiners who will be conducting the practical and the marks should be awarded out of 75. Questions for Theory & Practical are to be set by the concerned examiners.

Course Outcomes

At the end of the course, the student will be able to:

1. Carryout the analyses for various basic experimental designs and interpretation.
2. Apply the factorial experimental designs.

Solve the problems related to transition probability, classification of states and time series modeling.

Skill Enhancement Course - III	**23PSTAS45: Computational Statistics Using R**	**Credit**	**2**
II Year		**Hours/ Week**	**4**
IV Semester			

Pre-requisite

Basic computer programming knowledge

Objectives of theCourse

To enable the students to develop computational and technical skills for real life applications emphasizing the importance of R programming.

Course Outline

Unit I:

Introduction to R – Using the help facility. R data types and objects, reading and writing data import and export. Data structures: vectors, matrices, lists and data frames – Built-in data- Reading data from other sources – Merging data across data sources.

Unit II:

Control structures: functions, scoping rules, dates and times – Grouping, loops and conditional execution – Ordered and unordered factors – Arrays and matrices – Classes and methods – Graphical procedures.

Unit III:

Dealing with Missing values – Data Cleaning and Transforming, Exploring and Visualizing – Writing your own functions – Statistical models in R.

Unit IV:

Descriptive statistics – Frequency and contingency tables – correlations – t-tests, Nonparametric tests of group differences: Comparing two groups – Comparing more than two groups.

Unit V:

Distributions and Modeling – Regression – ANOVA – General linear models – Principal component analysis and factor analysis.

Books for study

1. Purohit, S.G., Gore, S.D., & Deshmukh, S.R. (2009). *Statistics using R.* Narosa Publishing House, New Delhi.
2. Peter Dalgaard, Introductory Statistics with R(Paperback) 1st Edition Springer-Verlag New York, Inc.

Books for Reference

1. An Introduction to R. Online manual at the R website at http://cean.r-project .org/manuals.html.
2. Brian Everitt and Torsten Hothorn, (2009), A Handbook of Statistical Analysis Using R, 2nd Edition Chapman and Hall/CRC.
3. Robert Kabacoff, R, (2011), Action Data Analysis and Graphic with R, Manning Publications.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for thissubject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Accessing and processing of data.
2. Understanding the types, classes and functions of R programming.
3. Conduct and interpret the variety of Hypothesis tests.
4. Analyze the different types of data obtained from the real world.
5. Understand, analyze and interpret ANOVA

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Week

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	S	S	M	S	M
CO2	S	M	S	S	M	S	S	M	M	M
CO3	S	S	S	M	S	S	S	S	M	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	S	M	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	443	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Extension Activity	**23PSTAX46: Extension Activity**	**Credit**	**1**
II Year		**Hours/ Week**	**-**
IV Semester			

(Refer to the regulations)

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the basics of python and data structures.
2. Apply suitable built-in data structures to solve the problem.
3. Understand various methods in file handling.
4. Understand the use of pandas.
5. Design and program python applications.

Non Major Elective Courses
(For other Department Students)

Non Major	**23PSTAO: Statistics for Social Sciences**	**Credit**	**2**
I Year		**Hours/ Week**	**4**
II Semester			

Pre-requisite
Basic Mathematics and Statistics
Objectives of theCourse
Students can learn advanced contents in statistics with application for business and economics. At the end of the course students will be able to understand, interpret and apply several statistical methods and models commonly used in the analysis of data.

Course Outline
Unit I: Partial correlation-Partial correlation coefficient-Partial correlation in case of four variables, Multiple correlation -Multiple regression.

Unit II: Theory of probability - probability rules – Baye's theorem - Probability distribution-Characteristics and application of Binomial, Poisson and Normal distribution.
Unit III: Sampling- sampling methods- sampling error and standard error- relationship between sample size and standard error. Testing of hypothesis- testing of means and proportions-large and small samples- Z test and't' test.
Unit IV: Chi square distribution- Characteristics and applications- test of goodness of fit and test of independence- Test of Homogeneity of variances.
Unit V: F test for attributes- testing equality of population variances- Analysis of variance-one way and two way classification.

Note:
1. **The emphasis is only on the application of the methods. The derivations of the formulae are not necessary.**
2. **The proportion between theory and problems shall be 20:80.**

Recommended Text
1. Gupta, S.P. (2000). *Statistical Methods.* Sultan Chand & Sons, New Delhi.
2. Samcheri, D.C & Kapoor, V.K. *Business Statistics*. Sultan Chand and sons, New Delhi.

Reference Books
1. Richard I Levin & David S. Rubit (2002). S*tatistics for Management* (7th ed.). Pearson Education, New Delhi.
2. Sharma. K, *Business Statistics*- Pearson Education.

Website and e-Learning Source
e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to
1. Know Partial and Multiple correlations.
2. Know Probability and discrete distributions.
3. Understand the Sampling technique, Hypothesis, Z-Test and t-test.
4. Have the awareness about application of Chi- Square distribution.
5. Know about Analysis of Variance and F-test.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Non Major	**23PSTAO: Statistics for Life Sciences**	**Credit**	**2**
I Year		**Hours/ Week**	**4**
II Semester			

Pre-requisite

Basic Mathematics and Statistics

Objectives of theCourse

Students can learn advanced contents in statistics with application for business and economics. At the end of the course students will be able to understand, interpret and apply several statistical methods and models commonly used in the analysis of data.

Course Outline

Unit–1

Definition, scope, functions and limitations of Statistics – Collection, Classification, Tabulation of data, Diagrammatic representation of data – Simple, Multiple and Percentage Bar diagram, Pie diagram and Graphical representation of data – Histogram, frequency polygon, frequency curve and ogives. Primary and Secondary data – Questionnaire method.

Unit–2

Measures of Central tendency – Mean, Median and Mode and their practical usages. Measures of Dispersion: Range, Quartile Deviation, Mean Deviation, Standard Deviation, Variance and Coefficient of Variation. Measures of Skewness – Pearson's, Bowley's method.

Unit–3

Measure of Bivariate data – Simple, Partial and Multiple Correlation. Scatter diagram, Pearsons method and Rank correlation method. Regression and their equations – Prediction. Basic concept of Sampling – Parameter and Statistics – Sampling distribution and Standard Error – Simple random sampling and stratified random sampling.

Unit–4

Tests of Significance with their important concepts. Tests for large samples - Test for mean, difference of means, proportion and equality of proportions. Small sample tests – Test for mean, difference of Means, paired samples, test for correlation and regression coefficients.

Unit– 5

Chi square test for goodness of fit and independence of attributes. F-test – Analysis of variance, Assumptions, Applications, one way ANOVA and two way ANOVA classifications. Note: The emphasis is only on the application of the methods. The derivations of the formulae are not necessary.

Books for Study and References:

1. Gupta, S.P., (2011), Statistical Methods, Sultan Chand & Sons, Pvt. Ltd, New Delhi
2. Gupta, S.C and V.K. Kapoor, (2011), Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Pvt. Ltd, New Delhi

Book for Study and References

1. Darren George, Paul Mallery, (2011), SPSS for Windows, 10th Edition, PEARSON

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Know Partial and Multiple correlations.
2. Know Probability and discrete distributions.
3. Understand the Sampling technique, Hypothesis, Z-Test and t-test.
4. Have the awareness about application of Chi- Square distribution.
5. Know about Analysis of Variance and F-test.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

Non Major	**23PSTAO: Optimization Techniques**	**Credit**	**2**
II Year		**Hours/ Week**	**4**
IV Semester			

Pre-requisite
Basic Mathematics

Objectives of theCourse

To enable the students to learn optimization techniques viz., graphical method, simplex programming, transportation and assignment problem, game problem and network model.

Course Outline

Unit I: Linear Programming Problems
Introduction to Operations Research - Meaning and scope-Characteristics-Models in operations research. Linear Programming Problems- graphical method- Simplex method.

Unit II: Transportation Problems
Transportation model-Basic feasible solution-formulation-solving transportation problems-North West Corner Rule -Least Cost Method -Vogel's Approximation Method - Optimality Test-MODI method.

Unit III: Inventory Models
Inventory Models- Types of Inventory- Inventory Costs- Deterministic Inventory Model-EOQ models with shortages and without shortages.

Unit IV: Game Theory
Two Person Zero Sum Game, Maximin and Minimax Principle, Games without Saddle Point, Mixed Strategies, Graphical Solution of 2Xn and mX2 Games. Sequencing- n Job through 2 Machines and n jobs through 3 Machines.

Unit V: Network Analysis
Network Analysis -Work Breakdown analysis -construction-numbering of events. Programme Evaluation and review Technique (PERT)- Critical Path Method (CPM).

Note:

1. **The emphasis is only on the application of the methods. The derivations of the formulae are not necessary.**
2. **The proportion between theory and problems shall be 20:80.**

Recommended Text

1. Swarup, K., Gupta, P.K and Man Mohan. *Operations Research*. Sultan Chand & Sons, NewDelhi.
2. Kapoor, V.K. *Introduction to Operational Research.* Sultan Chand & sons, New Delhi.
3. Sharma, S.D. (2010). *Operations Research*. Kedar Nath Ram Nath, Meerut.

Reference Books

1. Gupta, P.K.,& Man Mohan. *Problems in Operation Research.* Sultan Chand and Sons, New Delhi.
2. Hillier, F.S. & Lieberman, G.J.(2005). *Introduction to Operations Research* (9th ed.). Mc Graw Hill, New York.
3. Prem Kumar Gupta & Hira, D.S. (2010). *Problems in Operations Research.* Sultan Chand and Company Limited, New Delhi.
4. Rao, S.S. (1972).*Optimization: Theory and Applications.* Wiley Eastern (P) Ltd., New Delhi.

Website and e-Learning Source

e-books, online tutorials taken from MOOC/SWAYAM platform for this subject.

Course Learning Outcome (for Mapping with POs and PSOs)

Students will be able to

1. Understand the linear programming problems.
2. Analyse the transportation problems with different methods.
3. Learn inventory models.
4. Understand the concept of game theory.
5. Apply network analysis practically.

CO-PO Mapping (Course Articulation Matrix) S-Strong, M-Medium, W-Weak

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	M
CO2	S	M	S	S	M	M	S	M	M	M
CO3	S	S	S	M	S	S	S	M	S	M
CO4	S	S	S	S	S	S	S	M	M	M
CO5	S	M	S	S	S	S	S	M	M	S

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0