**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** |  |  |  |  |  |
| Part 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 |
|  | Elective – I | 3 | 5 | 25 | 75 | 100 |
| 23PSTAE14-1 | Categorical Data Analysis |  |  |  |  |  |
| 23PSTAE14-2 | Population Studies |  |  |  |  |  |
|  | Elective-II  | 3 | 5 | 25 | 75 | 100 |
| 23PSTAE15-1 | Bayesian Inference |  |  |  |  |  |
| 23PSTAE15-2 | Clinical Trials |  |  |  |  |  |
|  |  | **Total** | **20** | **30** |  |  | **500** |
|  |  | **SEMESTER – II** |  |  |  |  |  |
| Part 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 |
|  | Elective – III  |  |  |  |  |  |
| 23PSTAE24-1 | Actuarial Statistics / | 3 | 4 | 25 | 75 | 100 |
| 23PSTAE24-2 | Simulation Analysis |  |  |  |  |  |
|  | Elective – IV  |  |  |  |  |  |
| 23PSTAE25-1 | Survival Analysis / | 3 | 4 | 25 | 75 | 100 |
| 23PSTAE25-2 | Econometrics |  |  |  |  |  |
| Part B | 23PSTAS26 | Skill Enhancement Course (SEC-I):Statistics Practical – I (Practical) | 2 | 4 | 25 | 75 | 100 |
|  |  | **Total** | **22** | **30** |  |  | **600** |

**Component wise Credit Distribution**

| **Credits** | **Sem I** | **Sem II** | **Sem III** | **Sem IV** | **Total** |
| --- | --- | --- | --- | --- | --- |
| **Part A** | 20 | 20 | 22 | 20 | **82** |
| **Part B****(i) Discipline – Centric / Generic Skill (Skill Enhancement Courses)** | - | 2 | 2 | 2 | **6** |
| **(iii) Summer Internship / Industrial Training** | - | - | 2 | - | **2** |
| **Part C** | - | - | - | 1 | **1** |
| **Total** | **20** | **22** | **26** | **23** | **91** |

#

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

**Department Elective Courses**

| **Semester** | **Group****(Choose any one from each group)** | **Course Code** | **Course Title** | **C** | **H/W** |
| --- | --- | --- | --- | --- | --- |
| **I** | **A** | 23PSTAE14-1 | Categorical Data Analysis | 3 | 5 |
| 23PSTAE14-2 | Population Studies | 3 | 5 |
| **I** | **B** | 23PSTAE15-1 | Bayesian Inference | 3 | 5 |
| 23PSTAE15-2 | Clinical Trials | 3 | 5 |
| **II** | **C** | 23PSTAE24-1 | Actuarial Statistics | 3 | 4 |
| 23PSTAE24-2 | Simulation Analysis | 3 | 4 |
| **II** | **D** | 23PSTAE25-1 | Survival Analysis | 3 | 4 |
| 23PSTAE25-2 | Econometrics | 3 | 4 |

| **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](https://www.google.co.in/search?hl=en&sxsrf=APwXEdeJ0_XA8ZZA8AJvC4dLDK777G8iKA:1687079465870&q=inauthor:%22Shein-Chung+Chow%22&tbm=bks), [Jen-Pei Liu](https://www.google.co.in/search?hl=en&sxsrf=APwXEdeJ0_XA8ZZA8AJvC4dLDK777G8iKA:1687079465870&q=inauthor:%22Jen-Pei+Liu%22&tbm=bks), (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 rth 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 rth 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://www.mathforum.org/), [http://ocw.mit.edu/ocwweb/Mathematics,](http://ocw.mit.edu/ocwweb/Mathematics)

[http://www.opensource.org](http://www.opensource.org/), [www.mathpages.com](http://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).
1. **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.
1. **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 |