

SRI VENKATESWARA UNIVERSITY :: TIRUPATI**SVU COLLEGE OF SCIENCES****Department of Statistics****Re-Structured P.G. Programme (CBCS) as per NEP 2020, National Higher Education
Qualification Frame Work (NHEQF) and Guidelines of APSCHE****(With effect from the batch of Students admitted from the academic year 2024-25)****MASTER OF SCIENCES (Statistics)**

SEMESTER - I								
S. No	Course	Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	CC	101	Probability and Distributions	4	4	70	30	100
2		102	A. Linear Algebra	4	3	50	25	75
			B. Statistical Finance					
3		103	A. Sampling Techniques	4	3	50	25	75
			B. Bayesian Inference					
4		*P 104	Practical-I (ST 102 & ST 103)	6	2	35	15	50
5	SOC	105	A. Statistical Analysis using SPSS and Excel	4	3	50	25	75
			B. Measure Theory					
6		106	A. Stochastic Process	4	3	50	25	75
			B. Computer Programming					
7	*P	107	Practical-II(ST 105 & ST 106)	6	2	35	15	50
			Total	36	20	340	160	500
8	Audit Course	109	Research Methodology	4	0	0	100	0

- CC (Core Courses) - 1st Core Course is mandatory and 2nd & 3rd Core Courses Student can choose one from each code
- *SOC (Skill Oriented Courses) – Student can choose one from each code
- *Practical – I relating to 2nd & 3rd Core Courses and Practical - II relating to 1st & 2nd Skill Oriented Courses (SOC)

Audit Course – Zero Credits but mandatory with only a Pass

ST 101: PROBABILITY AND DISTRIBUTIONS

Unit-I: Classes of sets, fields, σ -fields, minimal σ -field, Borel σ -field in $\mathbb{R}^K$, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Lebesgue and Lebesgue-Stieltjes measures, Measurable functions, Random variables, sequence of random variables, almost sure convergence, convergence in probability (and in measure). Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem.

Unit-II: Expectation of a random variable, inequalities on expectations, Markov, Holder, Jensen and Liapounov inequalities. Borel-Cantelli - Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Chebyshev's theorem, Khinchine's theorem, Kolmogorov theorems (statements only), convergence in distribution.

Unit-III: Laplace and Weibull distributions. Functions of random variables and their distributions, sampling distributions: central Chi Square, t and F distributions and their properties, applications, relation between t and F, F and χ^2 ; Fisher's Z-distribution, Fisher's Z-transformation. Non-central chi-square, t and F distributions and their properties.

Unit-IV: Multiple and partial correlation coefficients, multiple linear regression, inter relationship among partial and multiple correlation and regression coefficients. Null distributions of simple, partial and multiple correlation coefficients. Order statistics and their distributions, joint and marginal distributions of order statistics, distribution of range. Extreme values and their asymptotic distributions.

References

1. Ash, Robert. (1972). Real Analysis and Probability. Academic Press.
2. Billingsley, P. (1986) Probability and Measure. Wiley.
3. Kingman, J F C and Taylor, S. J. (1966). Introduction to Measure and Probability. Cambridge University Press.
4. Loeve, M (1963), Probability theory
5. Bhatt B.R (1998), Modern Probability theory, Wiley Eastern
6. Rohatgi V.K. (1984): An Introduction to probability theory and mathematical Statistics.
7. Rao C.R (1973): Linear Statistical Inference and its Applications, 2/e, Wiley Eastern.
8. Pitman J. (1993): Probability, Narosa Publishing House.
9. Johnson, N.L and Kotz, S.M. (1972): Distributions in Statistics, Vol. I , II & III. Houghton and Mifflin.
10. David H.A (1981): Order Statistics, II Edition, and John Wiley.
11. Feller W (1966): Introduction to probability theory and its applications, Vol. III, second edition. Wiley Eastern.

Subject Code	Subject Name	Credits Allotted		Total
ST-101	Probability and Distributions	Theory	Practical	4
		4	---	
Course Objective	1. To Explain about classes of sets and Probability measures 2. To discuss on random variables and convergence in probability and the important theorems with proofs. 3. To discuss about inequalities on expectations with their derivations and laws of numbers. 4. To explain about different discrete and continuous distributions and their Properties. 5. To learn about derivations and properties of various sampling distributions. 6. To explain order Statistics and their properties			
Course Out comes	1. Students must have knowledge about random variables, expectations, sets and their properties and inequalities where ever necessary. 2. Students also know the weak law, strong law and central limit theorem and their importance 3. Students know about different continuous and discrete distributions and their properties. 4. They have awareness about central and non central sampling distributions and order Statistics. Idea about simple, partial and multiple correlation coefficients.			

ST-102(A): Linear Algebra

Unit-I: Algebra of matrices; Elementary transformations; Rank and Inverse of a matrix; Nullity; Partitioned matrices; Kronecker product; Generalized inverse of matrix; Moore-Penrose generalized inverse; Solutions of simultaneous equations.

Unit-II: Finite dimensional Vector Spaces; Vector Spaces and Subspaces; Linear dependence and independence; Basis and dimension of a vector space; Completion theorem; Inner product Spaces; Orthonormal basis and Gram-Schmidt orthogonalization process; Orthogonal projection of a vector.

Unit-III: Linear transformations and properties; Orthogonal and unitary transformations; Real quadratic forms; Reduction and classification of quadratic forms; Hermitian forms; Sylvester's law of inertia; Canonical reduction of quadratic form.

Unit-IV: Characteristic roots and vectors; Cayley – Hamilton theorem; Minimal polynomial; Similar matrices; Spectral decomposition of a real symmetric matrix; Reduction of a pair of real symmetric matrices; Hermitian matrices.

References

1. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd ed. Wadsworth, Belmont (California).
2. Rao, C. R. (1985). Linear statistical inference and its applications, Wiley Eastern Ltd., New Delhi.
3. Searle, S. R. (1982). Matrix Algebra useful for Statistics, John Wiley and Sons. Inc.
4. Bellman, R. (1970), Introduction to Matrix Analysis, 2nd ed. McGraw Hill, New York.
5. Campbell, H.G. (1980), Linear Algebra with Applications, 2nd Edition, Prentice-Hall, Englewood Cliffs (new Jersey), 1980.
6. Biswas, S. (1984), Topics in Algebra of Matrices, Academic Publications.
7. Hadley, G. (1987), Linear Algebra, Narosa Publishing House.
8. Halmos, P.R. (1958), Finite-dimensional Vector Spaces 2nd ed. D. Van Nostrand Company, Inc.
9. Hoffman, K. and Kunze, R. (1971). Linear Algebra, 2nd ed., Prentice Hall
10. Rao, A.R. and Bhimasankaram, P. (1992), Linear Algebra, Tata McGraw Hill Publishing Company Ltd.
11. Rao, C.R. and Mitra, S.K. (1971), Generalized Inverse of Matrices and its Applications, John Wiley and Sons, Inc.
13. Narayan, S. (1970), Theory of Matrices, S. Chand & Company, New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
ST-102(A)	Linear Algebra	Theory	Practical	4
		4	---	
Course Objective	1. To Prepare Students about algebra of matrices and vector spaces. 2. To explain about roots vectors and linear transformations with an examples			
Course Out comes	Students understood for estimation of elementary transformations in matrix and their solutions. Students learnt about characteristic roots and vectors with numerical examples. They also know theoretical proofs of theorems.			

ST-102(B): Statistical Finance

Unit I

Basic concepts of financial markets and financial systems. Functions of financial markets. Interest rates, continuous compounding, present value analysis - effective interest rate, present value and future value. Modeling returns: lognormal model, random walk model, modeling through geometric Brownian motion process. (10 hrs)

Unit II

Portfolio theory – mean variance portfolio theory. Risk and return, risk free interest rate. One risky asset and one risk free asset. Two risky assets. Sharpe's ratio, tangency portfolio, optimal mix of portfolio. Market portfolio, beta, security market line, and capital asset pricing model (CAPM) and their assumption.

Value at Risk (VaR) – Nonparametric and parametric estimation of VaR , VaR for a derivative and for a portfolio of assets. (10 hrs)

Unit III

Forward contracts and Futures. Call and put options, European option and American options, short and long positions. Financial derivatives, options, pricing via arbitrage, law of one price. Risk neutral valuation, arbitrage theorem. Risk neutral probabilities- Binomial model, and multi-period model. (10 hrs)

Unit IV

The Black-Scholes formula and assumptions. Properties of the Black-Scholes option cost. Delta, gamma and other Greeks.

Volatility and estimating the volatility parameter. Implied volatility. Pricing American options. Call options on dividend-paying securities. (10 hrs)

References

1. Sheldon M. Ross (2003): “*An elementary introduction to Mathematical Finance*”, Cambridge University Press.
2. David Ruppert (2004) “*Statistics and Finance an Introduction*” – Springer International Eddition.
3. John C. Hull (2008) “*Options, Futures and other derivatives*”, Pearson Education India.
4. Cuthbertson K and Nitzsche D (2001): “*Financial Engineering - Derivatives and Risk Management*”, John Wiley & Sons Ltd.
5. David G Luenberger(1998): “*Investment Science*”, Oxford University Press.
6. Paul Wilmott (2000): “*Quantitative Finance*”, John Wiley & Sons.

Course Outcomes:

- 1: The ability to model the returns.
- 2: The ability to understand the basic concepts of financial system.
- 3: The ability to explain portfolio theory.
- 4: The ability to understand Black Scholes properties and assumptions.
- 5: The ability to deal with forward contracts and futures

ST 103 (A): Sampling Techniques

Unit-I: Review of basic concepts of sampling theory such as sampling design, sampling scheme, sampling strategy etc., Sampling with varying probability with and without replacement, PPS WR/WOR methods – Lahiri's sample scheme, Hansen – Hurwitz, Des Raj estimators for a general sample size and Murthy estimator for a sample of size 2, Symmentrized Des Raj estimator.

Unit-II: Hurwitz – Thompson estimator (HTE) of a finite population total / mean, expression for $V(HTE)$ and its unbiased estimator. IPPS scheme of a sampling due to Midzuno – Sen and JNK Rao (sample size 2 only). Rao – Hartley-Cochran sampling scheme for a sample of size n with random grouping.

Unit-III: Ratio and Regression methods of estimation, Two stage sampling, Multi stage sampling, Cluster sampling. Resampling methods and its applications.

Unit-IV: Double sampling for difference, ratio, regression and PPS estimators; Large scale sample surveys, Errors in surveys, A mathematical model for errors of measurement, Sampling and Non-sampling errors, Sources and types of non-sampling errors, Remedies for non-sampling errors.

References

1. Chaudhuri. A and Mukerji. R (1988): Randomized Response Theory and Techniques, New Yory, Marcel Dekker Inc.
2. Cochran W.G (1988): Sampling Techniques III Edition (1977) Wiley.
3. Des Raj and Chandak (1988): Sampling Theory. Narosa.
4. Murthy M.N (1977): Sampling Theory and Methods. Statistical Publishing Society.
5. Sukhatme et al (1984): Sampling Theory of Surveys with Applications. Iowa State University Press & IARS
6. Sing D and Chudary F.S (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.
7. Hedayat A.S and Sinha B.K. (1991): Design and Inference in Finite Population Sampling. Wiley.
8. Mukhopadhyay P(1996): Inferential problems in Survey Sampling. New Age International.
9. Wolter K.M (1985): Introduction to Variance Estimator. Springer. Verlag.
10. Hansen M.M and Hurwitz W.M and Mandow W.G (1954): Sample Survey Methods and Theory, Vol. I and Methods and Applications Vol. II, John Wiley and Sons.
11. Philli. I. Good (2013):Introduction to statistics through resampling methods and R, 2nd edition.

Subject Code	Subject Name	Credits Allotted		Total
ST-103 (a)	Sampling Techniques	Theory	Practical	4
		4	----	
Course Objective	1. Discuss about basic concepts of sampling techniques PPS WR/WOR models. 2. To study about Hurwitz Thompson estimator, PPS scheme. 3. To learn about Ratio and Regression methods and their properties. 4. To explain Double sampling for difference estimators using ratio regression and PPS's, Non sampling error and their remedies.			
Course Out comes	1. Students learnt different sampling techniques of with replacement/ without replacement and Different sampling models. 2. Students studied Non-Sampling errors and different remedies.			

ST 103 (B): Bayesian Inference

Unit-I

Limitations of empirical and logical theories of probability, Subjective probability, determination of subjective probability, likelihood function, prior distribution, posterior distribution. Bayes' theorem, methods of construction of priors and computation of the posterior distribution.

Natural conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension.

Unit-II

Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non informative, improper and invariant priors. Jeffrey's invariant prior.

Unit-III

Bayesian point estimation: As a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0-1 loss function.

Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.

Unit-IV

Bayesian interval estimation: Credible intervals. Highest posterior density regions.

Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

Bayesian testing of hypothesis: Specification of appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases.

References:

1. Bernardo J.M. and Smith A.F.M.: Bayesian Theory, John Wiley.
2. Berger J.O. (1988): Statistical Decision Theory and Bayesian Analysis, Springer- Verlag, New York Inc.
3. Degroot M.H.: Optimal Statistical Decisions, McGraw Hill.
4. Ghosh J.K., Delampady M. and Samanta T. (2006): An Introduction to Bayesian Analysis: Theory and Methods, Springer.
5. Leonard T. and Hsu J.S.J. (1999): Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers, Cambridge University Press.
6. Robert C.P. and Casella G.: Monte Carlo Statistical Methods, Springer-Verlag.

Course Outcomes:

- 1: Explain in detail the Bayesian framework for data analysis and its flexibility and be able to demonstrate when the Bayesian approach can be beneficial.
- 2: Develop, analytically describe, and implement both single and multi parameter probability models in the Bayesian framework.

- 3: Demonstrate the role of the prior distribution in Bayesian inference and be able to articulate the usage of non-informative priors and conjugate priors.
- 4: Show high level Interpretation of Bayesian Analysis Results and be able to readily perform Bayesian model evaluation and assessment.
- 5: Demonstrate the necessary skills to: fit hierarchical models, provide thorough technical specifications for these models.
- 6: Perform Bayesian computation using Markov chain Monte Carlo methods

ST 104: Practical-I (ST 102 & ST 103)

ST 105 (A): Statistical Analysis using SPSS and Excel

Unit-I: Review of Excel, sorting, filtering and construction of charts. Curve fitting and interpretation of the output. Statistical functions in Excel - Calculating theoretical probability using Binomial, Poisson and Normal distributions. Matrix operations- Transpose, Product and Inverse operations using Excel. Pivot tables and look up functions.

Unit-II: Data Analysis Pak in Excel, descriptive statistics, tests of hypothesis, ANOVA, Correlation and Regression, Random Number Generation from different distributions, Binomial, Poisson, Uniform, Normal and from discrete distributions with given mean and variance. Forecasting Using Excel – Moving Averages and Exponential Smoothing, Use of functions, Linest, Logest, Forecast, Growth, Trend for trend analysis. The use of solver for optimization – Application to LPP.

Unit-III: Introduction to SPSS, Different Menu's in SPSS, creating a data file, opening excel files, variables and labels, selecting cases by filtering, recoding of data, merging of files, Sorting of Cases and Variable, SPSS Output and its transfer to excel and word. Analysis categorical data- Scales of Measurements, Data reliability-test rest method, Cronbach's alpha.

Unit-IV: Using SPSS Analysis tools, descriptive statistics, cross tabs (with stress on procedures and syntax). Post-hoc analysis for multiple comparisons using Tukey's test, Duncan's Multiple Range Test, Dunnet's test and Scheffe's test with interpretation. Selection of variables in Multiple Linear Regression – stepwise procedures and analysis of residuals. Procedure for Binary Logistic regression, Factor analysis, Linear Discriminant analysis and Cluster analysis.

ST 105 (B): Measure Theory

Unit –I: Field and Sigma Field. Measure and Probability Measure. Outer Measurability of Sets. Class of Measurable Sets. Construction of Outer Measure using Sequential Concerning Classes. Lebesgue Measure. Construction of Non-Measurable Sets.

Unit –II: Measurable Function as a Random Variable. Simple Functions. Sequences and Algebra of Measurable Functions. Approximation Theorem of Measurable Functions. Concepts of Almost Everywhere (a.e) and Almost Uniform Convergence. Egoroffs Theorem. Lusin Theorem.

Unit –III: Convergence in Measure. Fundamental in Measure. F.Riesz Theorem for Convergence in Measure. Integral of a Measurable Function w.r.t a Measure. Bounded Convergence Theorem. Fatou's Lemma, Monotone Convergence Theorem. General Lebesgue Integral and Lebesgue Dominated Convergence Theorem.

Unit –IV: Linear and Orthogonal Transformation of a Matrix. Eigen Values and Eigen Vectors of a Linear Transformation. Quadratic Forms and Their Reduction to Canonical Form. Signature of a Matrix. Positive Definite Matrix.

References

1. Burtil, C.W. : Measure Theory and Probability
2. Halmos, P.R. : Measure Theory
3. Royden, H.L : Real Analysis
4. Munroe, M.E. : Introduction to Measure and Integration
5. Kingman .J.F.C. : Introduction to Measure and Probability and Taylor,S.J.
6. Data, K.B. : Matrix and Liner Algebra
7. Hadley, G. : Liner Algebra
8. Sushma, V. : Liner Algebra

ST 106 (A): Stochastic Process

Unit-I: Introduction to stochastic processes (sp's): classification of sp's according to state space and time domain. Countable state Markov chains (MC's), Chapman – Kolmogorov equations, calculation of n – step transition probability and its limit. Stationary distribution, classification of states,, transient MC, random walk and gambler's ruin problem.

Unit-II: Discrete state space continuous time MC: Kolmogorov – Feller differential equations, Poisson process, birth and death process; Applications to queues and storage problems. Wiener process as a limit of random walk, first – passage time and other problems.

Unit-III: Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem, study of residual life time process: weakly stationary and strongly stationary process; Moving averages and auto regressive process.

Unit-IV: Branching process: Galton – Watson branching process, probability of ultimate extinction, distribution of population size. Martingale in discrete time, inequality, convergence and smoothing properties. Statistical inference in MC and Markov process.

References

1. Adke, S.R and Manjunath, S.M (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Bhat, B.R (2000): stochastic Models: Analysis and Applications, New Age International, India.
3. Cinlar, E (1975): Introduction to Stochastic Processes, Prentice Hall.
4. Feller, W (1968): Introduction to Probability and its Applications, Vol. 1, Wiley Eastern.
5. Harris, T.E (1963): The Theory of Branching Processes, Springer – Verlag.
6. Hoel, P.G., Port, S.C and Stone, J.C (1972): Introduction to Stochastic Processes, Houghton Mifflin & Co.
7. Jagers, P (1974): Branching Process with Biological Applications, Wiley.
8. Karlin, S and Taylor, H.M (1975): A First Course in Stochastic Processes, Vol. 1, and Academic Press.
9. Medhi, J (1982): Stochastic Processes, Wiley Eastern.
10. Parzen, E (1962): Stochastic Processes, Holden – Day.

Subject Code	Subject Name	Credits Allotted		Total
ST-103 (b)	Stochastic Process	Theory	Practical	4
		4	----	
Course Objective	1. To explain stochastic process and their classification according to space and domain. 2. To discuss about Birth and death process, Renewal theory and its applications, stochastic process and their importance, Markov chains, Poisson process, Renewal theory, Branching process etc.			
Course Out comes	1. Students understoodstochastic processes, Markov chains, Poisson process, Renewal theory, Branching process, etc.			

ST 106 (B): Computer Programming

Unit-I: Introduction to Fortran 77, Data Type, Operators and Expressions, Assignment Statement, Arithmetic and Logical Operation, List Directed and Format-Directed Input/Output Statement. Control Statements, Arrays, Dimension Statement, User Defined Function, Function Subprograms, Subroutine Subprograms, Builtin-Functions.

Unit-II: Introduction to C++. Structure of a C++ Program. Creating the Source Files. Compiling and Linking, C++ Programming Basics: Input/Output, Data Types, Operators, Expressions, Control Structures, Library Functions, Functions In C++ : Passing Arguments to and Returning Values From Functions, Inline Functions, Default Arguments, Function Overloading.

Unit-III: Classes and Objects : Specifying and Using Class and Object, Arrays Within A Class, Arrays of Objects, Object As A Function Arguments, Friendly Functions, Pointers to Members, Constructors and Destructors. Operator Overloading and Type Conversions. Inheritance: Derived Class and Their Constructs, Overriding Member Functions.

Unit – IV: Pointers to Objects, This Pointer, Pointers to Derived Classes, Virtual Functions, Streams, Stream Classes, Unformatted Input/Output Operations, Formatted Console Input/Output Operations, Managing Output with Manipulators, Opening and Closing A File. File Pointers and Their Manipulations, Error Handling During File Operations.

References

1. Ram Kumar : Introduction to Fortran-77 Tata McGraw Hill
2. Rajaraman, V : Computer Programming in Fortran 77, Prentice-Hall India
3. William, E. M. & Cwiakala, M. : Programming with Fortran-77, Tata McGraw Hill
4. I.S. Robert Lafore : Object Oriented Programming using C++, Sams Publications :
5. E. Balagurusamy : Object Oriented Programming with C++, Tata McGraw Hill
6. Byron S. Gottfried : Object Oriented Programming using C++, Tata McGraw Hill

ST 107: Practical-II(ST 105 & ST 106)

ST 108: OOTC

ST 109: Research Methodology

UNIT – I: Introduction to Research: Meaning and importance of Research, Types of Research, Research Design and Stages Selection and Formulation of Research Problem, Objective(s) and Hypothesis Developing Research Plan – Exploration, Description, Diagnosis, Experimentation, Determining Experimental and Sample Design. Data Collection: Sources of Data – Primary and Secondary, Types of Data – Categorical (nominal and ordinal), Numerical (discrete, continuous, ratio and interval) Methods of Data Collection: Survey, Interviews (in-depth or Key Informant interviews), Focus Group Discussion (FGD), Observation, Records or Experimental Observations.

UNIT – II: Data Processing and Analysis: Statistical Graphics – Histograms, Frequency Polygon, Ogive, Dotplots, Stemplots, Bar Graphs, Pareto Charts, Pie Charts, Scatterplots, Boxplots Descriptive Analysis – Frequency Distributions, Measures of Central Tendency, Measures of Variation/Dispersion, Skewness and Kurtosis, Measures of Relative Standing Qualitative Approaches Including Grounded Theory, Ethnography, Narrative Inquiry, Phenomenology and Case-Study.

UNIT – III: Scientific Writing & Research Ethics: Structure and Components of Scientific Reports – Types of Report – Technical Reports and Thesis – Significance – Different steps in the preparation – Layout, Structure and Language of Typical Reports – Illustrations and Tables – Bibliography, Referencing and Foot Notes.

UNIT-IV: Preparation of the Project Proposal: Title, Abstract, Introduction – Rationale, Objectives, Methodology – Time frame and Work Plan – Budget and Justification – References. Research Ethics Committees/Institutional Review Board – Roles and Importance Intellectual Property rights – Commercialization, Royalty Reproduction of Published Material – Citation and Acknowledgement, Plagiarism.

SEMESTER – II								
S. No	Course	Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	CC1	ST 201	Multivariate Analysis	4	4	70	30	100
2	CC2	ST 202	A: Design of Experiments	4	3	50	25	75
			B: Decision Theory and Sequential Analysis					
3	CC3	ST 203	A: Statistical Inference	4	3	50	25	75
			B: Generalized Linear Model					
4	*P	ST 204	Practical III- (ST - 202 and ST – 203)	6	2	35	15	50
5	SOC	ST 205	A: Linear Methods and Applied Regression Analysis	4	3	50	25	75
			B: Order Statistics					
6		ST 206	A : Statistical Process and Quality Control	4	3	50	25	75
			B: Survey Sampling					
7	*P	ST 207	Practical IV (ST - 205 and ST - 206)	6	2	35	15	50
	OOTC	ST 208	OOTC	--	2	--	--	--
8	Audit Course	ST 209	Advanced Analytical Skills	4	0	0	0	0
			Total	36	22	340	160	500

ST 201: MULTIVARIATE ANALYSIS

Unit-I: Multivariate normal distribution, marginal and conditional distributions, characteristics functions, Maximum likelihood estimators of parameters, distribution of sample mean vector and dispersion matrix, distribution of quadratic form in the exponent of the multivariate normal density.

Unit-II: Hotelling's T^2 and its applications – T^2 distribution, application of T^2 to single sample, two sample and multiple sample problems, optimum properties of T^2 test. Mahalobis D^2 statistic and its distribution, Multivariate Analysis of Variance (MANOVA) of one and two-way classified data.

Unit-III: Classification and discrimination: procedures for classification into two multivariate normal populations, Fisher's Discriminant function, classification into more than two multivariate normal populations, Wishart distribution and its properties, concept of sample generalized variance and its distribution.

Unit-IV: Principal Component Analysis – properties, method of extraction of principal components; Canonical variables and canonical correlations; Factor Analysis – mathematical model, estimation of factor loading, concept of factor rotation; Cluster Analysis – similarities and dissimilarities, Hierarchical clustering: single and complete linkage method.

References

1. Anderson, T.W (1983), An introduction to Multivariate Statistical Analysis, Wiley, 2nd Edition.
2. Rao, C.R (1973), Linear Statistical Inference and its applications, 2nd edition, Wiley
3. Srivastava. M.S and Khatri, C.G (1979), An introduction to Multivariate Statistics, North Holland
4. Morrison,F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
5. Johnson A.R and Wishern, D.W (1996), Applied Multivariate Statistical Analysis, Prentice Hall of India
6. Sharma, S (1996), Applied Multivariate Techniques, Wiley
7. Krishisagar, A.M (1972), Multivariate Analysis, Marcel Dekker
8. K.C. Bhuyan(2005): Multivariate Analysis and its Applications, Central

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
		4	----	
ST 202	Multivariate analysis			4
Course Objective	1. To study about Multivariate normal distributions and their properties, it's importance. 2. To discuss Hotelling's T^2 , Mahalanobis D^2 statistic and its applications and properties. 3. To explain MANOVA with one and two way classified data. 4. To discuss about Principal Component Analysis, Factor Analysis and Cluster Analysis with appropriate methods.			
Course Out comes	1. Students learnt about importance of multivariate variables and their distributions 2. T^2 , D^2 , MANOVA models are understood and know it's importance. 3. Classification analysis methods explained according to their classification algorithm.			

ST 202 (A) : DESIGN OF EXPERIMENTS

Unit-I: Linear Model; Estimability of linear parametric functions; BLUE, Gauss-Markoff theorem; Generalized Gauss-Markoff theorem, ANOVA model, ANOVA for Two way and three way classifications, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey's, Duncans, Sheffe's and Dunnet's tests.

Unit-II: Latin squares and their construction, Mutually orthogonal Latin squares; Missing plot technique in Latin square Design, Graeco-Latin square Design; Analysis of Factorial Experiments involving factors with two and three levels in randomized blocks.

Unit-III: Necessity of confounding, Types of confounding, complete and partial confounding in 2^n , 3^2 and 3^3 factorial designs, Analysis of confounded factorial designs; Fractional Replication, Split Plot design.

Unit-IV: Incomplete Block Designs; B I B D, Inter and Intra Block analysis of a BIBD, Types of BIBD, construction of BIBD's using Mutually orthogonal Latin squares; Concepts of Youden square and lattice Design, Two-Associate PBIB design, Analysis of P B I B design.

References

1. M.N. Das and N.C.Giri (1979), Design and Analysis of Experiments, Wiley, Eastern, Pvt. Ltd., New Delhi.
2. C.D. Montgomery (1976), Design and Analysis of Experiments, Wiley & Sons, New York
3. M.C.Chakbravorthy, (1962), Mathematics of Design of Experiments, Asia Publishing House, Calcutta.
4. Oscar Kempthorne (1974), The Design and Analysis of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.

5. W.T. Federer (1972), Experimental Designs Theory and Application, Mac Millan Company, New York.
6. Angela Dean and Daniel Ross (1999), Design and Analysis of Experiments, Springer-Verlag.
7. D.D.Joshi (1987), Linear Estimation and Design of Experiments, Wiley Eastern, Pvt. Ltd., New Delhi.
8. P.W.M.John (1971), Statistical Design and Analysis of Experiments, Macmillan
9. F.Pukelshiem (1993), Optimal Design of Experiments, Wiley & Sons
10. D.Raghava Rao (1971), Construction and combinatorial problems in Design of Experiments, Wiley & Sons
11. Aloke Day (1986), Theory of Block Designs, Wiley Eastern, Pvt. Ltd., New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
ST 202(A)	Design of Experiments	Theory	Practical	4
		4	----	
Course Objective	1. To learn ANOVA and ANCOVA for one and two way classifications analysis and their multiple comparison tests. 2. To explain Latin squares, different types of Latin squares and their missing plots. 3. To discuss on Confounding, their types, confounding 2^n, 3^2 and 3^3 factorial designs etc. 4. To discuss about BIBD, PBIBD construction analysis.			
Course Out comes	1. Students learnt ANOVA, ANCOVA technique for one way and two-way classifications. Multiple comparisons tests using Tukey's, Duncans, Sheffe's and Dunnet's tests. 2. Students understood about Latin squares and their construction, missing plot technique etc. 3. Students explained about Incomplete Block Designs and their analysis, etc.			

ST 202(B): Decision Theory and Sequential Analysis

Unit-I: Elements of decision theory: Expected loss, decision rules and risks - Bayesian expected loss, frequentist risks, randomized and nonrandomized decision rules, admissible decision rule, complete, essential complete and minimal complete classes of decision rules and their relationship, minimax and Bayes decision rule, estimation testing viewed as decision rule problem, Bayes and minimax estimators. Minimax and Bayes tests in simple cases.

Unit-II: Decision principles: the conditional Bayes decision principle and frequentist decision principles. Misuse of classical Inference procedures, the frequentist perspective, the conditional perspective, the likelihood principle, choosing a paradigm or decision principle. Utility theory: introduction, the utility of money.

Unit-III: Bayesian decision theory: Posterior decision analysis, estimation, finite action problems and hypothesis testing. Minimax Analysis: Introduction, game theory, basic elements, general techniques for solving games, finite games, the minimax theorem.

Unit-IV: Sequential Decision rule: Stopping rule, terminal decision rule. Bayes and minimax sequential decision Rules. Invariant sequential decision problems, sequential test of a simple hypothesis. The sequential probability ratio test, the fundamental identity of sequential analysis.

Course Objective

The main objective of this course is to provide the detailed knowledge of the decision theory and sequential analysis.

Course Outcomes:

After completing this course, student is expected to learn the following:

CO1: Understand the concept of decision theory and sequential analysis.

CO2: Learn how to perform posterior decision analysis and hypothesis testing.

CO3: Understand the decision rule and fundamental identity in sequential analysis.

CO4: Learn the wider applications of decision principles of Bayesian and frequentist approaches.

ST 203(A): Statistical Inference

Unit-I: Point estimation –Unbiasedness, Consistency, Efficiency and Sufficiency; Fisher-Neyman factorization theorem, complete sufficient statistics, minimum variance unbiased estimator (MVUE), Cramer - Rao inequality, Battacharayyas inequality, Rao – Blackwell theorem. Exponential family, Maximum Likelihood estimation method, method of moments, method of minimum chi-squares and interval estimation.

Unit-II: Tests of hypothesis: Basic concepts, Most Powerful (MP) test, Neyman – Pearson Lemma, Consistency and Unbiased tests, Uniformly Most Powerful (UMP) test, UMP Unbiased tests, similar critical regions, Lehmann –Scheffe theorem, Likelihood Ratio Tests, Asymptotic Distribution of LR test, Bartlett's test for homogeneity of variances and Wald Test.

Unit-III: Non – Parametric tests of significance; Sign Test, Wilcoxon-Mann-Whitney U-test, Run test, Kolmogorov-Simrnov one and two sample tests, Median test, Kendall's τ test. Concept of asymptotic relative efficiency, CAN, BAN, CAUN and BEST CAUN estimators, MLE in Pitman family and Double Exponential distribution, MLE in Censored Truncated distribution.

Unit-IV: Statistical decision theory – decision problems and two person games, problems of inference viewed as decision problems, non-randomized and randomized decision rules, Loss and Risk functions, admissibility, complete and essentially complete class, complete class theorem. Bayes principle, determination of Bayes rule Minimax principle, determination of minimax rule, minimax theorem. Minimax estimates of parameters of Binomial, Poisson and Normal distributions.

References:

1. Rohtagi, V.K (1988): An Introduction to Probability and Mathematical Statistics, Wiley Eastern
2. Rao C.R (1973), Linear Statistical Inference and its applications, (Revised Edition), Wiley Eastern
3. Lehmann, E.L (1986), Theory of point estimation, (Student Edition)
4. Lehmann, E.L (1986), Testing Statistical Hypothesis (Student Edition)
5. Gibbons, J.D (1985), Non-parametric statistical inference, 2nd Edition, Mercel Dacker Inc
6. Siegal Sidney (1987), Non-parametric Statistics for behavioral sciences, 3rd Edition, Springer Verlag
7. Kendal, M.G and Stuart, A (1968), The advanced theory of statistics, Vol-II, Chales Griffin and Co., London
8. Ferguson, T.S (1967), Mathematical Statistics – a decision theoretic approach, Academic Press
9. Goon, A.M, Gupta, M and Das Gupta, B (1980), An outline of statistical theory, Vol-II, World Press, Calcutta.

Subject Code	Subject Name	Credits Allotted		Total
ST 203(A)	STATISTICAL INFERENCE	Theory	Practical	4
		4	----	
Course Objective	1. To study the Estimation methods of point and their different measures and theorems, inequality. 2. To discuss about Testing of hypothesis that contains NP Lemma, UHP test, Bartlett’s, Wald test, LR test and some theorems relates to hypothesis testing. 3. To discuss different Non-parametric tests with examples. Asymptotic relative efficiency and truncated distributions. 4. To study the Game theory and their problems, minimax rule, minimax theorem and minimum estimates of parameters using different distributions.			
Course Applied regression Out comes	Students know about point estimation, testing of hypothesis, Non parametric models, Game theory, theorems and Proofs where ever necessary.			

ST 203(B): Generalized Linear Model

Unit-I: Review of linear regression models, Residual Analysis, Transformation of response variable- Box-cox Method, Nonlinear regression models, Estimation of parameters and Statistical Inferences in nonlinear regression, Introduction to generalized linear models.

Unit-II: Logistic and Poisson regression models: Logistic regression model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, Goodness-of-Fit tests (Concept of deviance), analysis of deviance, Lack-of-Fit tests in Logistic regression. Concept of overdispersion in logistic regression. Introduction to Poisson regression, MLE for Poisson regression, Applications in Poisson regressions.

Unit-III: Log linear models for contingency tables: interpretation of parameters, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, and partial association. Graphical and decomposable models.

Unit-IV: Family of Generalized Linear Models: Exponential family of distributions, Formal structure for the class of GLMs, Link functions, Likelihood equations for GLMs, Important distributions for GLMs, A class of link functions-the power function, Inference and residual analysis for GLMs, Overdispersion, Quasi likelihood.

Course Objectives: The main objective of this course is to provide students the ability to learn and use linear and non-linear models for normal data, and generalized linear models for normal and non-normal responses.

Course Learning Outcomes:

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

1. Use linear and Non-linear models, apply data transformations, and appreciate the need and uses of generalized linear models.
2. Use logistic and Poisson regression models.
3. Understand deviance, analysis of deviance, Lack-of-Fit tests in Logistic and Poisson regression, and the concept of overdispersion.
4. Use Log linear models for contingency tables, and likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, and partial association.
5. Understand graphical and non-graphical models.
6. Use the concepts of Generalized Linear Models in real life problems.
7. Understand and apply Quasi likelihood.

Suggested Readings:

1. Agresti, A. (2002). Categorical Data Analysis, 2nd ed., John Wiley & Sons.
2. Bates. D.M. and Watts, D.G. (1988). Nonlinear Regression Analysis and Its Application, John Wiley & Sons.
3. Christensen, R. (1997). Log-linear Models and Logistic Regression, 2nd ed., Springer.
4. Collett, D. (2003). Modeling Binary Data, 2nd ed., Chapman and Hall, London.
5. Dobson, A.J. and Barnett, A.G. (2008). Introduction to Generalized Linear Models, 3rd ed., Chapman and Hall/CRC. London.

6. Green, P.J. and Silverman, B.W. (1994). Nonparametric Regression and Generalized Linear Models, Chapman and Hall, New York.
7. Hastie, T.J. and Tibshirani, R.J. (1990). Generalized Additive Models. 2nd ed., Chapman and Hall, New York.
8. Hosmer, D.W. and Lemeshow, S. (2000). Applied Logistic Regression, 2nd ed., John Wiley & Sons.
9. Lindsey, J. K. (1997). Applying generalized linear models, Springer-Verlag, New York.
10. Myers, R.H., Montgomery, D.C and Vining, G.G. (2002). Generalized Linear Models with Applications in Engineering and the Sciences, John Wiley & Sons.
11. McCulloch, C.E. and Searle, S.R. (2001). Generalized, Linear and Mixed Models, John Wiley & Sons.
12. McCullagh, P. and Nelder, J.A. (1989). Generalized Linear Models, 2nd ed., Chapman and Hall.

ST-204: Practical III- (ST - 202 and ST – 203)

ST- 205(A): Linear Methods and Applied Regression Analysis

Unit-I: Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2 .

Unit-II: Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model.

Unit-III: Analytical methods for selecting a transformation on study variable. Diagnostic for Leverage and Influence: Leverage, measures of influence. Generalized and weighted least square estimation. Polynomial Regression Models: Polynomial models in one variable. Orthogonal Polynomials. Piecewise polynomial (Splines). Variable Selection and Model Building: Incorrect model specifications. Evaluation of subset regression model. Computational techniques for variable selection.

Unit-IV: Logistic and Poisson regression models: Introduction, Linear predictor and link functions, logit, probit, odds ratio, maximum likelihood estimation, test of hypothesis. Generalized linear models: Exponential family of distribution, Linear predictors and link functions, Maximum likelihood estimation of GLM. Prediction and confidence interval with GLM.

Course Objective: The objectives of this course are to develop theoretical foundation of regression models and understand fundamental concepts of regression analysis.

Course Outcomes:

On completion of this course, students will be able to:

CO1: Understand simple and multiple linear regression models with their applications.

CO2: Learn the fitting of these models to simulated and real data sets.

CO3: Learn model adequacy using classical diagnostics, awareness of potential problems (outliers, etc.) and application of remedies to deal with them.

CO4: Understand the basic concepts of logistic, Poisson and generalized linear models.

Suggested Readings

1. Montgomery, D.C., Peck, E.A. & Vining, G.G. (2015). Introduction to Linear Regression Analysis, 5th Edition. Wiley.

2. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition. Wiley.

3. Draper, N.R. & Smith, H. (2011). Applied Regression Analysis, 3rd Edition. Wiley.

4. Chatterjee, S. and Hadi, A.S. (2012). Regression Analysis by Example, 5th Edition. Wiley.

5. Fox, J. and Weisberg, S. (2019). An R Companion to Applied Regression, 3rd Edition. Sage Publications.

ST-205(B): Order Statistics

Unit-I: Introduction to order statistics. Basic distribution theory. Joint and marginal distributions of order statistics in the continuous case. Distribution of the range and other systematic statistics. Conditional distributions. Order statistics as a Markov Chain. Order statistics for a discrete parent. Examples based on discrete and continuous distributions.

Unit-II: Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of the range. Approximations to moments in terms of the quantile function and its derivatives.

Unit-III: Moments of order statistics. Recurrence relations and identities for moments of order statistics from an arbitrary distribution. Recurrence relations for moments of order statistics from some specific distributions. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics.

Unit IV: Order statistics for independently and not identically distributed (i.n.i.d.) variates. Order statistics for dependent variates. Concomitants of order statistics. Random division of an interval and its applications. Order statistics from a sample containing a single outlier. Ballot theorem, its generalization, extension and application to fluctuations of sums of random variables. Concepts of record values and generalized order statistics.

Course Objectives: The objective of this course is to make the students aware of the properties and applications of order statistics.

Course Learning Outcomes:

On successful completion of the course the student will be able to:

1. Find joint, marginal and conditional probability distributions of order statistics in the continuous and discrete cases.

2. Find the distribution of sample range and other systematic statistics in case of sampling from an arbitrary continuous population and, in particular, from some specific continuous distributions such as uniform and exponential.

3. Understand the Markov Chain property of order statistics in the continuous case.
4. Learn how to obtain distribution-free confidence intervals for population quantile and distribution-free tolerance intervals for population distributions based on order statistics.
5. Understand the distribution-free bounds for moments of order statistics and of the range.
6. Find the approximations to moments of order statistics in terms of quantile function and its derivatives.
7. Derive the recurrence relations and identities for moments of order statistics drawn from an arbitrary population (discrete or continuous), as well as from some specific distributions.
8. Appreciate the large sample approximations to the mean and variance of order statistics as well as the asymptotic distributions of order statistics.
9. Find the distributions of order statistics for independently and not identically distributed variates and also for dependent variates.
10. Learn about the concomitants of order statistics and their properties.
11. Understand random division of an interval and its applications in geometrical probabilities.
12. Learn about the joint and marginal distributions of order statistics from a sample containing a single outlier.
13. Learn about the two candidates Ballot Box problem, its extension, generalization and application to fluctuations of sums of random variables.

References:

1. Arnold, B. C., Balakrishnan, N. and Nagaraja H. N. (2008). A First Course in Order Statistics, SIAM Publishers.
2. Arnold, B.C. and Balakrishnan, N. (1989). Relations, Bounds and Approximations for Order Statistics, Vol. 53, Springer-Verlag.
3. Ahsanullah, M., Nevzorav, V.B. and Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. David, H. A. and Nagaraja, H. N. (2003). Order Statistics, 3rd ed., John Wiley & Sons.
5. Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference, 3rd ed., Marcel Dekker.
6. Shahbaz, M. Q., Ahsanullah, M., Shahbaz, S. H. and Al-Zahrani, B. M. (2016). Ordered Random variables: Theory and Applications. Springer.
7. Takacs, L. (1967). Combinatorial Methods in the Theory of Stochastic Processes, John Wiley & Sons.

ST-206(A): Statistical Process and Quality Control

Unit-I: Basic concepts of quality, causes of variation, principle of Shewart's control chart, control charts for attributes and variables. Control limits and probability limits. Process monitoring and control, process capability, modified control chart. Capability indices C_p , C_{pk} , and C_{pm} . Concept of Six sigma and its relationship with process capability.

Unit-II: The OC and ARL of Shewart's control charts. Control by gauging, Moving Average and Exponentially Weighted Moving Average charts. CUSUM charts using V-mask and decision interval methods. Multivariate control charts – Control Ellipsoid, Hotelling's T^2 chart.

Unit-III: Acceptance sampling plans for attribute inspection – Type-A and Type-B OC curves. Single, double and sequential sampling plans and their properties. Sampling plans with rectifying inspection-concept of AOQ, AOQL. Design of Single sampling plan with given ATI.Plans for inspection by variables with one-sided and two-sided specifications.

Unit-IV: Sampling plans for continuous inspection-construction of Dodge CSP-1, CSP-2 and Multi level plans and their properties.Chain sampling and its applications.Design of Skip lot sampling plan and its ASN. Sampling plans with inspection error- derivation of AOQ and ATI in presence of errors.

References

1. Montgomery D.C (2009), Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance sampling in quality control Second Edition, Taylor & Francis.
3. Mittage, H.J and Rinne, H (1993): Statistical Methods of Quality Assurance, Chapman Hall, London, UK.
4. Ott. E.R (1975), Process Quality Control, Mc Graw Hill
5. Phadke, M.S (1989), Quality Engineering through Robust Design, Prentice Hall
6. Duncan, A.J (1974), Quality Control and Industrial Statistics, 3rd Ed., New York, Irwin.
7. Philip J. Ross (1989), Taguchi techniques for quality engineering, McGraw Hill

Subject Code	Subject Name	Credits Allotted		Total
ST – 206(A)	STATISTICAL PROCESS AND QUALITY CONTROL	Theory	Practical	4
		2	2	
Course Objective	1. To understand the basic concepts of control charts for variables and their indices. 2. To discuss different control charts like Shewart’s moving average, multivariate etc. with their applications. 3. To explain different sequential sampling plans and six sigma tool etc. with their properties and applications..			
Course Out comes	1. Students understood the basic concepts of control charts for variables and their indices. 2. Students performed different control charts like Shewart’s moving average, multivariate etc. with their applications. 3. Students used different sequential sampling plans and six sigma tool etc. in solving the problems.			

ST-206(B): Survey Sampling

Unit I: Basic ideas and distinctive features of sampling, Probability sampling designs, sampling schemes, inclusion probabilities and estimation. Review of important results in simple and stratified random sampling, Fixed (Design –based) and Superpopulation (modelbased) approaches. Non-sampling errors with special reference to non-response.

Unit II: Sampling with varying probabilities (unequal probability sampling) with or without replacement: pps, π ps and non- π ps sampling procedures and estimation based on them, Nonnegative variance estimation.

Unit III: Two-way stratification, post-stratification, controlled sampling, Estimation based on auxiliary data (involving one or more auxiliary variables) under design-based and modelM. based approaches, Double (two-phase) sampling with special reference to the selection with unequal probabilities in at least one of the phases.

Unit IV: Systematic sampling and its application to structured populations, Cluster sampling (with varying sizes of clusters), Two-stage sampling (with varying sizes of first-stage units), Warner’s and Simmons’ randomized response techniques for one qualitative sensitive characteristic.

Course Objectives: The main objective of this course is to learn techniques in survey sampling with practical applications in daily life which would be beneficial for the students to their further research.

Course Learning Outcomes:

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

1. Understand the distinctive features of sampling schemes and its related estimation problems
2. Learn about various approaches (design based and model-based) to estimate admissible parameters; with and without replacement sampling scheme, sampling with varying probability of selection.
3. Learn about the methods of post–stratification (stratified sampling) and controlled sampling and also double sampling procedure with unequal probability of selection.
4. Learn about the applications of sampling methods; systematic, stratified and cluster sampling.
5. Understand the cluster and two stage sampling with varying sizes of clusters/first stage units.
6. Understand the super population approach to estimation.
7. Learn about the randomized response techniques.

Suggested Readings:

1. Chaudhari, A. and Stenger, H. (2005). Survey Sampling Theory and methods, 2nd Edn., Chapman and Hall.
2. Chaudhari, A. and Vos, J.W.E. (1988). Unified Theory and Strategies of Survey Sampling, North –Holland, Amsterdam.
3. Cassel, C.M., Sarndal, C-E and Wretman, J.H. (1977). Foundations of Inference in Survey Sampling, Wiley Inter-Science, New York.
4. Cochran, W.G. (1977). Sampling Techniques, John Wiley & Sons, New York.

5. Hedayat, A.S., and Sinha, B.K. (1991). Design and Inference in Finite Population Sampling, Wiley, New York.
6. Levy, P.S. and Lemeshow, S. (2008). Sampling of Populations-Methods and Applications, Wiley, New York.
7. Murthy, M.N. (1967). Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
8. Raj, D. and Chandhok, P. (1998). Sample Survey Theory, Narosa Publishing House.
9. Mukhopadhyay, P. (2009). Theory and Methods of Survey Sampling, 2nd Edn., Prentice Hall of India, New Delhi.
10. Sarndal, C.E., Swensson, B. and Wretman, J.H. (1992). Model Assisted Survey Sampling, Springer-Verlag, New York.
11. Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press, Iowa, USA.
12. Thompson, S. K. (2002). Sampling, John Wiley & Sons, New York.

ST-207: Practical IV (ST - 205 and ST - 206)

ST-208: OOTC

ST-209: Advanced Analytical Skills

UNIT-I: Integral Transforms: Fourier transform for solution of ODEs and PDEs, Laplace transform for solution of ODEs and PDEs. Partial Differential Equations: solution of linear PDEs including special cases of heat conduction equation and Navier--Stokes equation, solution of PDEs in cylindrical and spherical coordinate systems.

UNIT-II: First-order integral equations: Fredholm, Volterra and Wiener-Hopf equation, power series solution for integral equations, integral equations as a generalization of eigenvalue equations and connection to inverse problems.

UNIT-III: Linear Algebra: spaces and subspaces, positive definiteness and singular value decomposition (best basis), transformations and change of basis, pseudoinverse, eigenvalues and eigenvectors, introduction to multigrid, Krylov subspaces and conjugate gradients methods for solving large linear systems.

UNIT-IV: Statistical Methods: probability, random variables, discrete and continuous probability distributions, autocorrelation and cross correlation, Monte-Carlo method for the solution of diffusion equation, radiative transfer equation and collimated beam radiation problem; linear regression and curve fitting.

Text Books:

1. B. Dasgupta, Applied Mathematical Methods, Pearson Education, 2006.
2. Sheldon M Ross, Probability and Statistics for Engineers and Scientists, 5/e, Academic Press, 2014.
- 3.

References:

1. M D. Greenberg, Advanced Engineering Mathematics, 2nd Edition, Pearson India, 2007.
2. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, International 10th Revised Edition, 2015.
3. G. Strang, Linear Algebra and Its Applications, Thomson, Brooks/Cole, 2006
4. P. V. O'Neil, Advanced Engineering Mathematics, CENGAGE Learning,, 2011.
5. R. L. Thomas and G. B. Finney, Calculus and Analytic Geometry, 11/e Addition Wisley Reading, 2010.
6. M. L. Boas, Mathematical Methods in the Physical Sciences, 3rd Ed, Wiley India, 2009.
7. A. D. Polyanin and A. V. Manzhirov, Handbook of Integral Equations, Second Edition, Chapman & Hall/CRC Press, Boca Raton, 2008.

SEMESTER – III								
S.no	Course	Code	Tittle of the course	H/W	C	SEE	IA	TOTAL Marks
01	CC	ST 301	Econometric Methods	4	4	70	30	100
02		ST 302	A: Bio Statistics B: Parametric Estimation	4	3	50	25	75
03		ST 303	A:Operations Research B: Statistical Testing in Data Analysis	4	3	50	25	75
04	P	ST 304	Practical – V (ST - 302 & ST - 303)	6	2	35	15	50
05	SOC	ST 305	A: Time Series Analysis B: Discrete Mathematics	4	3	50	25	75
06		ST 306	A: Demography and Official Statistics. B:Reliability Theory	4	3	50	25	75
07	P	ST307	Practical – VI(ST - 305 & ST - 306)	6	2	35	15	50
08		ST 308	OOTC					
*	Seminar/tutorials /remedial classes and quiz as part of internal assessment			4	0	0	0	0
			Total	36	22	340	160	500

ST-301: Econometric Methods

Unit-I: Introduction to Econometrics. Nature of econometric study. Simple linear regression, multiple linear regression, basic assumptions. Ordinary Least Squares (OLS) estimation and their properties. Use of prior information. Restricted least squares estimators Tests of hypothesis about regression coefficients and ANOVA. Mixed regression estimator.

Unit-II: Prediction – best linear unbiased predictor. Regression diagnostics and specification tests: Residual analysis for identifying influential observations, recursive residuals and their applications. Subset selection of explanatory variables, Mallows C_p -statistic. Introduction to Logistic regression model. Estimation and testing the significance of the coefficients.

Unit-III: Violation of basic ideal conditions: Disturbance with non-zero mean; asymptotically unco-operative regressors. Multicollinearity – its consequences and testing. Ridge estimator and its properties. Ridge regression. Stochastic regressors, autoregressive models, Instrumental variables, Errors in variables.

Unit-IV: Heteroscedasticity, tests for heteroscedasticity. Generalised Least Squares (GLS) estimators and its properties. Feasible generalized least squares estimators. Grouping of observations. Sets of Regression Equations. Auto correlation, its consequences and testing for autocorrelation. Estimation.

Course Outcomes:

CO1: A broad knowledge of regression analysis relevant for analysing economic data.

CO2: Learn estimation of model parameters ,inference problems in case of simple and multiple linear regression model

CO3: estimate the model parameters of regression model when some of the basic ideal conditions are violated

CO4: regression model adapted to cross section and time-series data

CO5: Learn to select the best subsets of regressors for the model.

CO6: Learn how to use estimated regression models for prediction.

CO7: Understand the estimation techniques and inference procedure in case of simultaneous equations model

References:

1. Badi H. Battagi (2002): Econometrics, 3rd Ed., Springer.
2. B.Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons
3. Draper N.R. and Smith H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons, Inc.
4. Dilip M. Nachane(2006): Econometrics-Theoretical Foundations and Empirical Perspective, Oxford University Press, New Delhi.
5. Fomby T.B., Hill R.C. and Johnson S.R. (1988) *Advanced Econometric Methods*, Springer- Verlag.
6. Greene W.H. (1993): Econometric Analysis, Macmillan, New York.
7. Johnston J. (1984): Econometric Methods, 3rd Ed., McGraw Hill.
8. Johnston J. and Dinardo J. (1997): Econometric Methods, 4th Ed., McGraw-Hill Companies.
9. G.S. Maddala (1977): Econometrics, McGraw-Hill Inc.

ST-302(A): Bio Statistics

Unit-I: Structure of Biological assay , Types of Biological assays: Direct assays, Potency ratio, Fieller's theorem, Behren's distribution, Two generalizations of Fieller's theorem.

Unit-II: Quantitative dose-response relationships, Linear dose-response regression, Parallel line bioassay, Slope Ratio Bioassay, Quantal responses, Estimation of median effective dose, Transformations: Probit and Logit transformations.

Unit-III:: Basic Biological concepts: Gene, Chromosomes, Alleles, Concepts of Genotypes and Phenotypes, Family studies, Basic mating from single gene cross, Matrix approach to basic matings of single gene cross, Checker board method, Mendel's law of heredity: Genotypes and Phenotype ratios, Branching system method.

Unit-IV: Types of matings, Random Mating, Concept of Gene pool, Gene frequency, Hardy-Weinberg law of equilibrium, Calculation of Gene frequencies, Genotypic frequency, Generation matrix approach to inbreeding, Estimation of Gene frequencies in ABO blood group system, Maximum Likelihood Method, Minimum Chi-Square method, Genetic parameters; Heritability Coefficients, Genetic Correlations, Repeatability, selection index; Inbreeding coefficient.

References

1. D.J. Finney (1971): Statistical Methods in Biological Assay, Charles Griffen and Company, London.
2. D.J. Finney (1971): Probit Analysis, 3rd Edition, S.Chand and Company Ltd, New Delhi.
3. William D. Stansfield. (1969): Theory and Problems of Genetics, Schaum's Outline Series, MC Graw Hill, New York.
4. Oscar Kempthorne (1973): An Introduction to Genetic Statistics, Jagmohan Book agency, New Delhi.
5. J.P. Jain (1992): Statistical Techniques in Quantitative Genetics, 2nd Edition, Hindustan Publishing House, New Delhi.
6. Basu, S. B. (1996), Quantitative Genetics Research Technique, Kalyani Publishers, New Delhi.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST 304 (b)	Bio-Statistics	4	----	4
Course Objective	1. To understand about Biological assay and their types, distribution and some of theorems. 2. To learn dose response relationships, their estimation, transformations. 3. To discuss Genotypes and phenotypes, Matrix operations to base matings of single gene cross etc. 4. To estimate Gene frequency using different methods.			
Course Out comes	Students learnt about Biological assay, their distribution and theorems, dose response relationships, basic concepts of biological assay, estimation methods of gene frequencies, etc.			

ST-302(B): Parametric Estimation

Unit-I: Sufficiency: Sufficient statistics, Fisher's information, Factorization theorem, minimal sufficiency, Lehman-Scheffe theorem, complete sufficient statistic, Sufficiency in Exponential family of distributions and Pitman family of distributions. Ancillary statistics. Basu's theorem & its applications.

Unit-II: Uniformly minimum variance unbiased estimators, Minimum Variance unbiased estimators, uniformly minimum variance unbiased estimators(UMVUE), Rao-Blackwell theorem, Lehmann-Scheffe theorem on UMVUE, Bhattacharya bounds, Minimum variance bound unbiased estimators.

Unit-III: Methods of Estimation: Method of maximum likelihood; minimum chi-square and modified minimum chi-square, Asymptotic properties of maximum likelihood estimator (MLE). Confidence interval estimation: Pivotal method of construction of confidence interval, confidence interval based on MLE.

Unit-IV: Bayes Estimation: Difference between classical method and Bayes method of estimation. Concept of prior and posterior distributions, squared error and weighted squared error loss functions to estimate parameters of binominal, Poisson, geometric, uniform, exponential and normal distributions.

Objectives: To provide an introduction to the fundamental theory of parametric estimation. Use classical and Bayesian approaches to formulate and solve problems for parametric estimation.

Outcomes: Upon satisfactory completion of the course, students become able to apply the different methods of parametric estimation to solve the problems in statistical inference. Students also become able to determine the distribution and statistical properties of estimator.

Books:

1. Mukhopadhyay, N. (2000): Probability and Statistical inference, Marcel Dekker.
2. Lehmann, E.L. (1983): Theory of Point estimation, Wiley Eastern.
3. Kale, B. K. (1999): A first course on parametric inference. Narosa publishing, New Delhi.
4. Rohatgi, V.K. & A.K. Md.E. Saleh (2001): An Introduction to Probability & Statistics, 2nd ed., John Wiley.
5. Zacks, S. (1971): Theory of Statistical Inference, John Wiley.
6. Dudewicz, E. J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley Eastern.
7. Goon, Gupta and Dasgupta. (1970): An outline of Statistical Theory, Vol. II, World Press, Calcutta.
8. Casella, G and Berger, R.L.(2002):Statistical Inference, Brooks/ Cole Publishing Co., Pacific Grove.
9. Box, G.E.P. and G.C. (1973): Bayesian inference in Statistical Analysis. Adison Wesley.
10. Rao, C.R.(1973): Linear Statistical Inference and its Applications, John Wiley.
11. Mood, A. M. Graybill, F. and Boes, D. C. (1974): Introduction to the Theory of Statistics, McGraw Hill.

ST-303(A): Operations Research

Unit-I: Definition and scope of Operations research; phases in Operations Research; models and their solutions (Review of Linear Programming). Definition of Dual-Primal, Relationships- Dual Simplex Sensitivity or Post Optimal Analysis, Revised Simplex method.

Unit-II: Non-linear programming - Kuhn Tucker conditions. Wolfe's algorithm for solving quadratic programming problems. Integer programming – Branch and bound algorithm and cutting plane algorithm.

Unit-III: Flows in networks max-flow-min-cut theorem. Project Management; PERT and CPM probability of project completion, PERT – crashing.

Unit-IV: Decision making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero- sum games, finding solution in 2×2 , and $2 \times m$, and $m \times n$ games. Non – zero sum games, co-operative and competitive games, equilibrium solutions and their existence in bi- matrix games. Nash equilibrium solution.

References

1. Taha H.A (1982) Operational Research: An Introduction; Macmillan.
2. Hiller F. Sand Leiberman G.J. (1962) Introduction to Operations Research; Holden Day
3. Kanti Swarup; Gupta P.K and Singh M.M (1985) Operations Research; Sultan Chand.
4. Philips D.T, Ravindran A and Solberg J Operations Research, Principles and Practice.
5. Churchman C.W; Ackoff R.L and Arnoff E.L(1957) introduction to Operations Research; John Wiley
6. Hadley G (1964) Non-Linear and Dynamic programming Addison Wesley.
7. Mckinsey J.C.C(1952) Introduction to the theory of games Mc Graw Hill.P.K.Gupta; D.S.Hira Operations Research S.CHand.

Subject Code	Subject Name	Credits Allotted		Total
ST-303(A)	Operations Research	Theory	Practical	4
		4	----	
Course Objective	1. To introduce operations research, Dual-primal, Revised simplex methods. 2. To discuss Non-linear programming and integer programming and their related problems. 3. To explain Network flow charts, CPM and PERT, project management models. 4. To discuss Game theory of 2×2 , $2 \times m$, $m \times n$ and non-zero sum games with their illustrations.			
Course Out comes	1. Students understood about Dual primal, Revised simplex methods. 2. Students learnt non-linear programming, integer programming, CPM, PERT, different models of games.			

ST-303(B): Statistical Testing in Data Analysis

Unit- I: Population and sample, parameter, statistic, estimator, statistical properties of estimators. Basic concepts concerning testing of hypotheses, procedure for hypothesis testing. Null hypothesis, alternate hypothesis, statistical test procedures, test statistic, two types of errors, level of significance, p-value, size and power of the test. One sided and two sided test procedures. Parametric and nonparametric tests.

Unit-II: Assumptions, test procedures and examples - One sample Z test, hypothesis testing of means, hypothesis testing for differences between means under equal variance and unequal variances, paired t-test, tests for proportions. Sample size and its determination.

Unit -III: Hypothesis testing for comparing a variance to some hypothesized population variance, testing the equality of variances of two normal populations, hypothesis testing of correlation coefficients, confidence intervals.

Unit-IV: Non-parametric tests, sign test, Wilcoxon signed rank test, Wilcoxon rank sum test- Mann- Whitney test, Contingency tables - Chi-square test for independence of attributes, Principles of design of experiments, basic principle of ANOVA, ANOVA – CRD, RBD, LSD.

Course Outcomes:

CO1: Demonstrate their knowledge of the basics of inferential statistics by making valid generalizations from sample data

CO2: Perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases. Understand the concept of p-values.

CO3: Learn non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit.

CO4: Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and F-test.

References:

1. J. Medhi (1992): Statistical Methods : An Introductory Text, Wiley Eastern Limited.
2. Douglas A. Lind, William C. Marchal, Samuel A. Wathen (2012), “Basic Statistics for Business & Economics” McGraw-Hill Education

ST-304: Practical – V (ST - 302 & ST - 303)

ST-305(A): Time Series Analysis

Unit-I: Review of Time Series Analysis. Growth models: Modified Exponential Curve, Gompertz curve, Logistic curve and their Fitting; Measurement of cyclical component: Harmonic analysis, auto regression series: Markoff and Yule's series, Periodogram and correlogram analysis, measurement of irregular component: variate difference method.

Unit-II: Need and uses of forecasting, classification and characteristics of forecasts, forecasting based on regression techniques: simple and multiple linear regression and non-linear regression techniques, moving averages smoothing methods: simple and double, multi average methods; explanatory version time series forecasting, test for trend seasonality.

Unit-III: Exponential smoothing methods: trend adjusted exponential smoothing, double and triple exponential smoothing, win ten's method, chow's adaptive control methods, brown's one parameter adaptive method: Box-Jenkins three parameter smoothing, Harrison's Harmonic smoothing methods, tracking signal.

Unit-IV: Box-Jenkin's time series methods: 1. Moving average 2. Autoregressive (AR) 3. ARMA and 4. AR integrated MA (ARIMA) models, estimation of ARIMA model parameters, forecasting with ARIMA models, Diagnostic checking of the model: Analysis of residuals, forecasting using transfer function model, concept of Kalmon's Filters.

References

1. Thomopouls, N.T (1980): Applied Forecasting Methods. Engle Wood Cliffs, N.J, Prentice Hall.
2. Wheel Wishart, S.C; and S. Makridaks (1980): Forecasting Methods for Management III edition, New York. John Wiley.
3. Sullivan, William G. and Wayne Claycambe. W (1977): Fundamentals of Forecasting, Prentice Hall. Virginia.
4. Gupta. S.C and V.K. Kapoor (1995): Fundamentals of Applied Statistics, Sulthan & Chand Sons. New Delhi.
5. Bovas, Abraham and Johannes Ledolter (1983): Statistical Methods for Forecasting, John Wiley & Sons. New York.
6. Box, G.E.P and Jenkkins, G.M (1976): Time Series Analysis Forecasting and Control, Holden Day, San Francisco.
7. Anderson, T.W (1971): The Statistical Analysis of Time Series, John Wiley, New York.
8. Markidakis, S Steven C. Wheel Wright and Victor E. Mcgee (1983): Forecasting: Methods and Applications, 2nd Edition, New York, John Wiley & Sons.

Subject Code	Subject Name	Credits Allotted		Total
ST305(A)	Time series Analysis	Theory	Practical	4
		4	----	
Course Objective	1. To fit growth curves, measurement of cyclical and irregular component with simple examples. 2. To discuss Forecasting and their techniques like regression, non-linear regression, exponential smoothing, etc. 3. To explain Box Jenkins time series models and their estimation of parameters, fitting and diagnostic checking.			
Course Out comes	1. Students understood about Time series analysis with some important growth models and their fitting. 2. Students learnt Forecasting using regression, non-linear regression techniques, single, double, triple and adoptive exponential smoothing models. 3. Students have experience in AR, MA, ARMA, ARIMA models fitting, diagnostic checking etc.			

ST-305(B): Discrete Mathematics

Unit- I: Logic: Propositional equivalence, predicates and quantifiers, Methods of proofs, proof strategy, sequences and summation, mathematical induction, recursive definitions and structural induction, program correctness.

Counting: The basics of counting, the pigeonhole principle, permutations and combinations, recurrence relations, solving recurrence relations, generating functions including-exclusion principle, application of inclusion-exclusion.

Unit-II: Relations: Relations and their properties, n-ary relations and their applications, representing relations, closure of relations, equivalence of relations, partial orderings.

Graph theory: Introduction to graph, graph terminology, representing graphs and graphs isomorphism, connectivity, Euler and Hamilton paths, planar graphs, graphs coloring introduction to trees, application of trees.

Unit-III: Group theory: Groups, subgroups, generators and evaluation of power, cosets and Lagrange's theorem, permutation groups and Burnside's theorem, isomorphism, automorphisms, homomorphism and normal subgroups, rings, integral domains and fields.

Unit-IV: Lattice theory: Lattices and algebras systems, principles of duality, basic properties of algebraic systems defined by lattices, distributive and complemented lattices, Boolean lattices and Boolean algebras, uniqueness of finite Boolean expression, propositional calculus theory: Coding of binary information and error detection, decoding and error correction.

References:

- 1) K.H. Rosen: Discrete Mathematics and its application, 5th edition, Tata McGraw Hill . Chapter 1(1.1-1.5), Chapter 3 (3.1-3.4,3.6), Chapter 4(4.1-4.3,4.5),Chapter6(6.1.2,4.4-6.6)Chapter7(7.1-7.6),Chapter8(8.1-8.5,8.7,8.8)
- 2) C.L.Liu: Elements of Discrete Mathematics, 2nd edition, TMH 2000. Chapter 11(11.1-11.10 except 11.7), Chapter 12(12.1 -12.8)
- 3) B.Kalman: Discrete Mathematical Structure, 3rd edition, Chapter 11(11.1,11.2)

ST-306(A): Demography and Official Statistics

Unit-I: Nature, Scope and limitations of demography; Sources of Demographic data in India; Measures of Mortality; life-tables; construction of abridged life table; Measures of fertility Stochastic models for reproduction, Reproduction rates: GRR and NRR; Concepts of Migration and Urbanization.

Unit-II: Population Projections: Stable and Stationary populations, Lotka's model; Use of Leslie matrix. Population estimates; Chandrasekhar and Deming's method, component method, Stochastic models of population growth, Exponential and logistic population growth models: Birth and death model, Birth-death and migration model.

Unit-III: Population Genetics: Concepts of Genotypes and Phenotypes; Basic Mating from Single gene cross, Punnett Square method, Mendel's laws of heredity; Random mating; Hardy-Weinberg Equilibrium law; Calculation of Gene frequencies, Estimation of Gene frequencies in ABO blood group system.

Unit-IV: Statistical systems in India; CSO, NSSO and their functions; scope and content of population Census in India; Methods of conducting population census, Economic census and Agricultural census in India and defects; Sources of forest statistics.

References

1. Suddender Biswas (1988), Stochastic Process in Demography and Applications, Wiley Eastern Ltd, New Delhi.
2. K.B. Pathak and F. Ram (1992), Techniques of Demographic Analysis, Himalayan Publishing House, Bombay.
3. Osacr Kempthorne (1973), An Introduction to Genetic Statistics, Jagmohan Book Agency, New Delhi.
4. William D. Stansfield (1969), Theory and Problems of Genetics, Schaum's Outline Series, MC Graw Hill, New York.
5. B.N. Gupta (1994), Statistics, Sahitya Bhavan, Agra.
6. B.L. Agrawal (1994), Basic Statistics, 2nd Edition, Wiley Eastren, New Delhi.
7. Asthana (1970), Indian Official Statistics.

Subject Code	Subject Name	Credits Allotted		Total
ST - 306(A)	Demography and official statistics	Theory	Practical	4
		4	----	
Course Objective	1. To study about demography and their importance, different reproduction. 2. To explain population Genetics, CSO, NSSO and their scope and contents in population census in India.			
Course Out comes	1. Students know the growth rates, life tables, GRR, NRR and growth models. 2. Students understood about gene frequencies, genotypes, phenotypes etc. 3. Students learnt about population census methods, organizations in India and their functions.			

ST-306(B): Reliability Theory

Unit –I: Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them; Notions of ageing – IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications; TTT transforms and characterization of ageing classes.

Unit –II: Non-monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma, Makeham, Rayleigh with reference to basic concepts and ageing characteristics; Bathtub and upside down bathtub failure rate distributions.

Unit –III: Discrete time failure models: – Definition of basic functions and their properties; Ageing classes and their mutual implications (IFR and DFR, IFRA and DFRA, NBU (NWU), NBUE, DMRL and IMRL, Discrete Time Failure

Models– geometric distribution, negative binomial distribution, discrete Weibull distributions,

Unit IV: Bivariate ageing classes – bivariate failure rate, bivariate IFR, bivariate IFRA, bivariate NBU, bivariate exponential distributions and their properties. concepts and measures of dependence in reliability – RCSI, LCSD, PF2, WPQD. Reliability estimation using MLE – exponential, Weibull and gamma distributions based on censored and non-censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models.

Text Books:

1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer.
2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern. 31

References:

1. Barlow R.E. and Proschan F. (1965). Mathematical Theory of Reliability, Wiley, New York.
2. Barlow, R.E. and Proschan, F. (1975). Statistical Theory of Reliability and Life Testing, Holt, Reinhart and Winston.
3. Marshall, A.W. and Olkin, I. (2007). Life Distributions, Springer.

ST-307: Practical – VI(ST - 305 & ST - 306)

ST-308: OOTC

SEMESTER- IV								
S.no	Course	Code	Tittle of the course	H/W	C	SEE	IA	TOTAL Marks
01	OOSTCs/ Papers in Department	ST 401	A: Advanced Econometric Methods B. Python	4	3	50	25	75
02		ST 402	A: Statistics For Research, Industry And Community development B: Agricultural Statistics	4	3	50	25	75
03	Practicle	403	Practical – VII (ST - 401 and ST - 402)	6	2	35	15	50
04	Project	404	Project Work – Orientation classes	14	12	65	35	100
		Conducting Classes for Competitive, Communications Skill UGC/CSIR and NET/SLET examinations		12	--	--	--	--
			Total	36	20	200	100	300
			Total Semester	144	84	1220	580	1800

ST-401 (A): Advanced Econometric Methods

Unit-I: Generalized linear Model; Aitken's theorem; GLS estimator, Asymptotic distribution of GLS estimator; Analysis of residuals, OLS, BLUEs and Recursive residuals; Studentized and predicted residuals; Granger's test of causality; nested and non nested statistical models; Cox and J tests.

Unit-II: Specification error; Consequences; specification bias; Ramsey's RESET test; Lagrange Multiplier test for adding variables; comparing two linear regression models; Dummy variable approach; Stepwise and Piecewise linear regression; Switching Regression Model.

Unit-III: Qualitative and limited dependent variable models; the linear probability model; probit model; Logit model and their estimation; concept of limited dependent variables; specification of Tobit model; concepts of censored and Truncated samples; estimation in censored and Truncated Samples.

Unit-IV: Sets of linear regression models; specification of the Seemingly Unrelated Regression Equations (SURE) model; OLS and GLS estimation of SURE model; Zellner's Feasible GLS estimator; Seemingly Unrelated Unrestricted Residuals (SUUR) estimator; Seemingly Unrelated Restricted Residuals (SURR) estimator; Reduction of the Zeller's Feasible GLS estimator to the OLS estimator.

References

1. Johnston, J (1984): Econometric Methods, III rd edition , MC Graw Hill.
2. Judge, C.G., Griffiths, and Hill, R.C. et al (1985): Theory and Practice of Econometrics, John Wiley.
3. Gujarathi, D (1979): Basic Econometrics, Mc Graw hill.
4. Srivastava, V.K and Giles, D.E.A (1987), Seemingly Unrelated Regression Equations Models: Estimation and Inference, Marcel Dekker, Inc
5. Cook. D and Weisberg. S (1982), Residuals and Inference in Regression, Chapman and Hall.

Subject Code	Subject Name	Credits Allotted		Total
		Theory	Practical	
ST401(A)	Advanced Econometric Methods	4	----	4
Course Objective	1. To explain OLS, GLS, BLUE and Recursive residuals with their properties. 2. To discuss different regression models and their importance. 3. To perform estimation in censored and Truncated Samples. 4. To fit sets of linear regression models and their related estimators.			
Course Out comes	1. Students understood GLM, SURE, nested and non nested statistical models. 2. Students learnt about specification error, adding, switching models. 3. Students performed Probit, logit models and their estimation.			

ST-401 (B): Python

UNIT – I:Introduction to Python Programming Language: Introduction to Python Language,Strengths and Weaknesses, IDLE, Dynamic Types, Naming Conventions, String Values, String Operations, String Slices, String Operators, Numeric Data Types, Conversions, Control Flow and Syntax, Indenting, The if Statement, Relational Operators, Logical Operators, True or False, Bit Wise Operators, The while Loop, break and continue, The for Loop, Lists, Tuples, Sets, Dictionaries, Sorting Dictionaries, Copying Collections, In Functions.

UNIT –II :Object and Classes : Classes in Python, Principles of Object Orientation, Creating Classes, Instance Methods, File Organization, Special Methods, Class Variables, Inheritance, Polymorphism, Type Identification, Custom Exception Classes.

UNIT –III : Functions and Modules : Introduction, Defining Your Own Functions, Parameters, Function Documentation, Keyword and Optional Parameters, Passing Collections to a Function, Variable Number of Arguments, Scope, Functions - "First Class Citizens", Passing Functions to a Function, Mapping Functions in a Dictionary, Lambda, Modules, Standard Modules – sys, □ Standard Modules – math, Standard Modules – time, The dir Function.

UNIT –IV : I/O and Error Handling In Python : Introduction, Data Streams, □ Creating Your Own Data Streams, Access Modes, Writing Data to a File, Reading Data From a File, Additional File Methods, Using Pipes as Data Streams, Handling IO Exceptions, Working with Directories, Metadata, Errors, Run Time Errors, The Exception Model, Exception Hierarchy, Handling Multiple Exceptions.

Books for Study:

1. Dive into Python, Mike
2. Learning Python, 4th Edition by Mark Lutz
3. Programming Python, 4th Edition by Mark Lutz

Course Outcomes:

- 1: Able to understand the concept of Python Programming.
- 2: Expertise in Object and Classes.
- 3: To be able to explore Functions and Modules learning.
- 4: Able to understand the concept of I/O and Error Handling In Python.

Course Out comes:

1. Students have done Python Programming and their Object and Classes.
2. Students have understand I/O and Error Handling In Python

**ST-402 (A): STATISTICS FOR RESEARCH, INDUSTRY AND
COMMUNITY DEVELOPMENT**

UNIT- I: Response Surface Designs: First and Second order Response Surface models; Rotatable designs; concept of connected design; outliers and Winsorized t - statistic; Stepwise regression; Specification of Random coefficients Regression model; Specification of variance components model; MINQUE Theory; Non parametric regression, the partially linear regression model.

UNIT-II: Simulation: Scope and limitations; Simulation models; Generation of RandomNumbers; Monte-Carlo simulation; Simulation of Queueing, Inventory Systems; Networks and Job sequencing. Data Envelopment Analysis (DEA): Non parametric approach to productive efficiency; Input, output correspondences for Frontier production function; Mathematical Programming for productive efficiency: Farrell and Timmer approaches with reference to Cobb-Douglas production function.

UNIT-III: Demand Analysis: Laws of Demand and Supply; price and partial elasticities of demand; Pigous method for Time Series and Family Budget data; Engel's curve; Pareto law of Income distribution; Production Functions: Basic concepts; Isoquants; Cobb-Douglas, CES and Translog Production functions and their properties and estimation; Tools for Data Mining.

UNIT-IV: Social Surveys for Community Development: Objects, Types of Social Survey; Steps in social survey; Gallop polls; Prephology, Data collection; Kinds of measurement; Scaling methods: Thurstone, Likert and Guttman methods; Concepts of Validity and Reliability; Methods of calculating reliability coefficients; Test Reliability; ANOVA for Ranked data: Kruskal-Wallis and Friedman tests; Elements of cluster analysis, Factor analysis., path coefficient analysis and Discriminant analysis.

References

1. Das, M.N. and Giri, N.C. (1979), Design and Analysis for Experiments, Wiley Eastern (P) Ltd., New Delhi.
2. Montgomery, C.D. (1976), Design and Analysis of Experiments, Wiley & Sons, New York.
3. Johnston, J., and Dinardo, J. (1997), Econometric Methods, Fourth Edition, Mc Graw-Hill International Editions, New York.
4. Judge., C.G., et.al (1985), Theory and Practice of Econometrics, John Wiley.
Taha, H.A. (1992), Operations Research, An Introduction, Fourth Edition

ST-402 (B): Agricultural Statistics

UNIT-I: History of Agricultural Development in India. Current Production Utilization and Growth Trends of Agricultural Commodities In India. Crop Improvement: Plant Breeding Traditional and Contemporary Methods, Plant Classification, Description and Economic Use of Field Crops. Biotechnological Tools for Crop Improvement, Plant Genetics Resources, Seed Quality Control, Seed Production Methods, Seed Sowing Methods, Seed Stages. Crop Production: Modern Approaches of Management of Pest and Disease, Principles of Plant Pathology.

UNIT-I I: Plant Science: Metabolic Processes and Growth Regulation, Climate Change, Reproduction, Post-Harvest Physiology, Soil Environment Microbiology, Bio-Fertilizer. Useful Organism: Honey Bees and Bee Keeping, Lack Insect and Silk Worm. Horticulture: Fundamental of Horticulture, Orchards Management, Breeding of Horticultural Crops,

Improvement of Fruit and Plantation Crops. Importance of Fruits and Vegetables In Human Nutrition. Contribution of Horticulture In National Economy and Export.

UNIT – III: Some Basic Genetical Terms, Statistical Analysis of Segregation, Detection and Estimation of Linkage. Gene and Genotypic Frequencies. Random Mating and Equilibrium In Large Populations. Disequilibrium Due To Linkages for Two Pairs of Genes and for Sex Linked Genes. Selection, Mutation and Migration. Equilibrium Between forces In Large Population. Polymorphism. Fisher's Fundamental Theorem of Natural Selection.

UNIT- IV: Polygenic Systems for Quantitative Characters, Concepts of Breeding Value, Dominance, Average Effect of Gene and Epistatic Interactions. Genetic Variance and Its Partitioning. Correlation Between Relatives. Regular System of Inbreeding, Effects of Inbreeding. Genotype and Environment Interaction, Stability Parameters.

References:

Falconer, D.S. : Introduction to quantitative Genetics (Longman Group Ltd.)
Kempthorne, O (1953) : An Introduction to Genetical Statistics, Wiley Eastern
Prem Narain : Statistical Genetics, Wiley Eastern
ICAR : Handbook of Agriculture, ICAR Publication.
Jain, J.P. : Statistical Technique in Quantitative Genetics (Tata Mc Graw, Hill
Publication Co. Ltd., New Delhi.

ST-403: Practical – VII (ST - 401 and ST - 402)

ST-404 Student Project

65 Marks for project thesis, 25 for project Viva Voce and 10 marks for Project presentation.
