AC/26.4.25/RS 1

College of Arts, Science & Commerce (Empowered Autonomous)

SIES

RISE WITH EDUCATION

NAAC REACCREDITED "A" GRADE

Sion (West), Mumbai – 400022.

Department of Statistics

Program: B.Sc.

Syllabus for T.Y.B.Sc.
Semester V & VI

(To be implemented from A.Y. 2026-27)

Credit Based Semester and Grading System
National Education Policy

SEMESTER V (MAJOR)

THEORY MAJOR

TITLE OF COURSE	THEORY OF ESTIMATION			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTMJ311	I	POINT ESTIMATION AND PROPERTIES OF ESTIMATOR	1	3
	II	METHODS OF ESTIMATION	1	
	III	BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL	1	
TITLE OF COURSE	PREDICTIVE MODELING			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTMJ312	I	LINEAR MODELS	1	3
	II	MULTIPLE LINEAR REGRESSION	1	
	III	CLASSIFICATION	1	
TITLE OF COURSE	ELEMENTS OF ACTUARIAL SCIENCE			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTMJ311	I	IKS - MORTALITY TABLES	1	3
	II	IKS - ANNUITIES CERTAIN LIFE ANNUITIES	1	
	III	LIFE ANNUITIES AND ASSURANCE BENEFITS	1	

PRACTICAL

COURSE CODE	PRACTICALS BASED ON	LECTURES/ WEEK	CREDITS
SIUSTMJP311	THEORY OF ESTIMATION	2	1
SIUSTMJP312	PREDICTIVE MODELING	2	1
SIUSTMJP313	ELEMENTS OF ACTUARIAL SCIENCE	2	1

THORY ELECTIVE

Learner can select one theory course as an elective course from the list of subjects and practical course based on the selected theory course.

TITLE OF COURSE	BIOSTATISTICS			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTEL311	I	EPIDEMIC MODELS	1	3
	II	BIOASSAYS	1	
	III	CLINICAL TRIALS AND BIOEQUIVALENCE	1	
SIUSTELP311	PRACTICAL BASED ON BIOSTATISTICS		2	1
TITLE OF COURSE	OPERATION RESEARH TECHNIQUES-I			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTEL312	I	LINEAR PROGRAMMING PROBLEM	1	3
	II	TRANSPORTATION PROBLEM	1	
	III	ASSIGNMENT PROBLEM AND SEQUENCING PROBLEM	1	
SIUSTELP312	PRACTICAL BASED ON OPERATIONS RESEARCH-I		2	1

SEMESTER VI (MAJOR)
THEORY MAJOR

TITLE OF COURSE	PROBABILTY AND DISTRIBUTION THEORY			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTMJ321	I	PROBABILITY	1	3
	II	JOINT MGF, TRINOMIAL AND MULTINOMIAL DISTRIBUTIONS	1	
	III	BIVARIATE NORMAL DISTRIBUTION	1	
TITLE OF COURSE	STOCHASTIC PROCESSES			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDIT S
SIUSTMJ322	I	ORDER STATISTICS	1	3
	II	STOCHASTIC PROCESSES	1	
	III	QUEUING THEORY	1	
TITLE OF COURSE	TESTING OF HYPOTHESES			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDIT S
SIUSTMJ323	I	MOST POWERFUL TESTS, UNIFORMLY MOST POWERFUL TESTS AND LIKELIHOOD RATIO TESTS	1	3
	II	SEQUENTIAL PROBABILTY RATIO TESTS	1	
	III	NON PARAMETRIC TESTS	1	

PRACTICAL

COURSE CODE	PRACTICALS BASED ON	LECTURES/ WEEK	CREDITS
SIUSTMJP321	PROBABILITY AND DISTRIBUTION THEORY	2	1
SIUSTMJP322	STOCHASTIC PROCESSES	2	1
SIUSTMJP323	TESTING OF HYPOTHESES	2	1

THORY ELECTIVE

Learner can select one theory course as an elective course from the list of subjects and practical course based on the selected theory course.

TITLE OF COURSE	TIME SERIES ANALYSIS			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTEL321	I	INTRODUTION TO TIME SERIES	1	3
	II	STATIONARITY AND AUTOCORRELATION	1	
	III	SMOOTHING, AUTOREGRESSIVE AND MOVING AVERAGE PROCESSES	1	
SIUSTELP321	PRACTICAL BASED ON TIME SERIES ANALYSIS		2	1

TITLE OF COURSE	OPERATIONS RESEARCH TECHNIQUES-II			
COURSE CODE	UNIT	TOPICS	LECTURES/ WEEK	CREDITS
SIUSTEL322	I	INVENTORY MODELS	1	3
	II	REPLACEMENT	1	
	III	SIMULATION	1	
SIUSTELP322	PRACTICAL BASED ON OPERATIONS RESEARCH TECHNIQUES-II		2	1

TYBSC SYLLABUS UNDER NEP
SEMESTER V
MAJOR 1

Objectives:

- To learn methods of estimation and properties of estimators.
- To use Bayesian approach in estimation.

Course Code	Title	Credits
SIUSTMJ311	**THEORY OF ESTIMATION**	**3**
Unit I: POINT ESTIMATION AND PROPERTIES OF ESTIMATOR Notion of a parameter and parameter space. Problem of Estimation, Definitions of Statistic, Estimator and Estimate. Properties of a good estimator. Unbiasedness: Definition of an unbiased estimator, biased estimator, positive and negative bias, Results on unbiased estimators. Consistency: Definition, Condition for consistency Sufficiency: Definition, Neyman Factorization Theorem and Sufficient statistic for Exponential family of probability distributions. Relative efficiency of an estimator. Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE.		**1**
Unit II: METHODS OF ESTIMATION Fisher information function**,** Cramer-Rao inequality, Cramer–Rao Lower Bound (CRLB), Definition of Efficient estimator using CRLB. Method of Maximum Likelihood Estimation (M.L.E.), Definition of likelihood as a function of unknown parameter, Properties of M.L.E. Method of Moments, Method of Minimum Chi-square and Modified Minimum Chi-square.		**1**
Unit III: BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL Bayesian Estimation: Prior distribution, Posterior distribution, Loss function, Risk function, Bayes' solution under Squared Error Loss Function (SELF) and Absolute Error Loss function. Interval Estimation: Confidence Interval. Definition of pivotal quantity and its use in obtaining confidence limits. Confidence Intervals based on asymptotic property of M.L.E. Equidistant confidence interval for the parameters of standard distributions.		**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ311	**<u>THEORY OF ESTIMATION</u>**	
Unit I: POINT ESTIMATION AND PROPERTIES OF ESTIMATOR **CO1:** Students will be able to Define and explain the properties of estimators including unbiasedness, consistency, and relative efficiency. **CO2:** Students will be able to Apply the Neyman Factorization Theorem and identify MVUE for standard distributions.		**R, U** **Ap, An**
Unit II: METHODS OF ESTIMATION **CO3:** Students will be able to Derive and interpret the Cramér-Rao Lower Bound using Fisher Information. **CO4:** Students will be able to Apply and compare MLE, Method of Moments, and Minimum Chi-square for parameter estimation.		**U, An** **Ap, E**
Unit III: BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL **CO5:** Students will be able to Formulate and evaluate Bayes estimators under Squared Error and Absolute Error Loss Functions. **CO6:** Students will be able to Construct and interpret confidence intervals using pivotal quantities and asymptotic MLE properties.		**An, E** **Ap, E**

SEMESTER V: PRACTICALS BASED ON COURSE THEORY OF ESTIMATION

1.	Minimum Variance Unbiased Estimator
2.	Method of Estimation -1
3.	Method of Estimation -2
4.	Bayes' Estimation
5.	Confidence Interval

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJP311	**<u>THEORY OF ESTIMATION</u>**	
CO1: Students will able to Solve and analyze numerical problems on unbiasedness, consistency, sufficiency, MVUE, and Cramér-Rao Lower Bound for standard probability distributions. **CO2:** Students will able to Compute and evaluate numerical problems on MLE, Method of Moments, Bayes estimators, and confidence intervals for standard distributions.		**Ap, An** **Ap, E**

<u>REFERENCES:</u>

1. Arora S. &Bansi Lal (1989) *New Mathematical Statistics*: Satya Prakashan,

New Delhi
2. Gupta S C & Kapoor V K. (2014). *Fundamentals of Mathematical Statistics*, Eleventh edition, Sultan Chand & Sons
3. HoelP.G.(1966). *Introduction to Mathematical Statistics*, Fourth Edition: John Wiley & Sons Inc.
4. Hogg R V. & Craig A. T. (2012).*Introduction to Mathematical Statistics,* Seventh edition: Pearson Education (Singapore) Pvt. Ltd.
5. Hogg R. V.&Tannis E. A. (2014). *Probability and Statistical Inference*, Ninth Edition: Collier McMillan Publishers.
6. Kapur J. N.&Saxena H.C. (2010) *Mathematical Statistics*, Fifteenth Edition : S. Chand & Company Ltd.
7. Rohatgi V.K.&Ehsanes Saleh A.K. Md.(2008). *An introduction to Probability Theory and Mathematical Statistics* , Second Edition: Wiley series in Probability and Statistics. Miller I., Miller M.& Freund J.E. (1999) *John E. Freund's Mathematical Statistics*, Sixth Edition: Pearson Education Inc.

MAJOR 2

Objectives:

- To distribute data into different classes on the basis of their characteristics.
- To comprehend modelling techniques used in prediction.

Course Code	Title	Credits
SIUSTMJ312	**<u>PREDICTIVE MODELING</u>**	**3**
Unit I:LINEAR MODELS Linear Regression Model $Y = X\beta + e$ where e follows Independent N(0, σ^2). Maximum Likelihood and Least square Estimators of β and σ^2. Properties of the estimators. Confidence Intervals for β and σ^2. Testing Significance of the regression coefficient β. Gauss-Markoff Theorem for Full rank Model. Properties of the Estimator, Estimation of Linear function of parameters λ'β Mean and variance. Confidence Interval and Testing of significance of λ'β.		**1**
Unit II: LINEAR REGRESSION Linear regression model with one or more explanatory variables. Assumptions of the model, Derivation of Ordinary Least Square (OLS) estimators of regression coefficients, (for one and two explanatory variables models). Properties of least square estimators (without proof). Coefficient of determination R^2 and adjusted R^2. Procedure of testing: Overall significance of the model, Significance of individual coefficients, Significance of incremental contribution of explanatory variable for two explanatory variables model. Confidence intervals for the regression coefficients. Autocorrelation: Concept, Detection using Run Test, Durbin Watson Test, Generalized Least Square (GLS) method. Heteroscedasticity: Detection using Spearman's Rank correlation test, Breusch-Pagan-Godfrey test. Weighted Least Square (WLS) estimators Multicollinearity: Detection using R square & t ratios, Variance Inflation Factor (VIF), Pairwise Correlation between regressors, Consequences of using OLS estimators in presence of autocorrelation, heteroscedasticity and multicollinearity. Multiple Linear Regression with Qualitative Independent Variable.		**1**
Unit III: CLASSIFICATION Logistic Regression Models: Introduction to Binary Logistic Regression, Statistical Model, Estimation of Parameters using MLE, Odds Ratio, Hosmer-Lemeshaw Test for goodness of fit, Classification Table. Concept of Multinomial and ordinal logistic regression. K-nearest-neighbor (kNN) Algorithm, Weighted kNN, Naïve Bayes. Decision Trees		**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ312	**PREDICTIVE MODELING**	
Unit I: POINT ESTIMATION AND PROPERTIES OF ESTIMATOR **CO1:** Students will be able to define and explain the Linear Regression Model, MLE and Least Square Estimators of β and σ^2, and their properties. **CO2:** Students will be able to interpret and apply Gauss-Markoff Theorem to derive confidence intervals and test significance of regression coefficients β and λ'β.		**R, U** **U, Ap**
Unit II: METHODS OF ESTIMATION **CO3:** Students will be able to explain and derive OLS estimators for one and two explanatory variable models and interpret R^2 and Adjusted R^2. **CO4:** Students will be able to detect and evaluate the problems of Autocorrelation, Heteroscedasticity, and Multicollinearity using appropriate diagnostic tests and remedial measures.		**U, Ap** **An, E**
Unit III: BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL **CO5:** Students will be able to explain and estimate parameters of Binary Logistic Regression using MLE and interpret Odds Ratio and goodness of fit. **CO6:** Students will be able to describe and implement classification algorithms including kNN, Naïve Bayes, and Decision Trees for predictive modeling.		**U, Ap** **U, Ap**

PRACTICALS BASED ON COURSE PREDICTIVE MODELLING

1. Linear Models
2. Linear regression model 1
3. Linear regression model 2
4. Logistic Regression
5. kNN and Naïve Bayes
6. Decision Trees

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJP312	**PREDICTIVE MODELING**	
CO1: Students will be able to solve and analyze numerical problems on OLS estimation, hypothesis testing of regression coefficients, and diagnostic tests for model assumptions. **CO2:** Students will be able to compute and evaluate numerical problems on Logistic Regression, kNN, and model selection criteria across standard datasets.		**Ap, An** **Ap, E**

<u>REFERENCES</u>:

1. Hastie, R. Tibshirani & J. Friedman. (2009) *The Elements of Statistical Learning, Data Mining, Inference and Prediction*,:Springer Series in Statistics.
2. HosmerD. W., Lemeshow Jr.& Sturdivant S, R. X.(2013). *Applied Logistic Regression*: John Wiley & Sons,
3. Montgomery D., Peck E. & Vining G. (2012).*Introduction to linear regression analysis*, Fifth Edition :Arizona State University. John Wiley & Sons, Inc.
5. Kshirsagar A.M.(1983).*A course in Linear Models*

MAJOR 3

Objectives:

- To comprehend Vital statistics
- To study formulation of policies in insurance industry

Course Code	Title	Credits
SIUSTMJ313	**ELEMENTS OF ACTUARIAL SCIENCE**	**3**
Unit I : MORTALITY TABLES Vital statistics: Meaning, Uses, Methods of obtaining Vital statistics. Various mortality functions. Probabilities of living and dying. The force of mortality. Estimation of μ_x from the mortality table. Central Mortality Rate. Laws of mortality: Gompertz's and Makeham's first law. Select, Ultimate and Aggregate mortality tables. Stationary and stable population. Expectation of life and Average life at death.		**1**
Unit II: ANNUITIES CERTAIN Accumulated value and present value, nominal and effective rates of interest. Varying rates of interest. Equation of value. Equated time of payment. Present and accumulated values of annuity certain (immediate and due) with and without deferment period. Present value for perpetuity (immediate and due) with and without deferment period. Present and accumulated values of increasing annuity, increasing annuity when successive installments form arithmetic progression, annuity with frequency different from that with which interest is convertible. Redemption of loan.		**1**
Unit III: LIFE ANNUITIES AND ASSURANCE BENEFITS Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with and without deferment period. Present values of variable, increasing life annuities and increasing Temporary life annuities (immediate and due). Present value of Assurance benefits in terms of commutation functions of : Pure endowment assurance, Temporary assurance, Endowment assurance, Whole life assurance, Special endowment assurance, Deferred temporary assurance Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Office premiums.		**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ313	**<u>ELEMENTS OF ACTUARIAL SCIENCE</u>**	
Unit I: MORTALITY TABLES **CO1:** Students will be able to define and explain vital statistics, mortality functions, probabilities of living and dying, and laws of mortality including Gompertz's and Makeham's first law. **CO2:** Students will be able to interpret and compute central mortality rate, force of mortality, expectation of life, and distinguish between select, ultimate, and aggregate mortality tables.		**R, U** **U, Ap**
Unit II: ANNUITIES CERTAIN **CO3:** Students will be able to define and explain present and accumulated values, nominal and effective rates of interest, equation of value, and types of annuities certain. **CO4:** Students will be able to interpret and calculate present and accumulated values of immediate, due, deferred, perpetuity, and increasing annuities including redemption of loans.		**R, U** **U, Ap**
Unit III: LIFE ANNUITIES AND ASSURANCE BENEFITS **CO5:** Students will be able to explain and compute present values of life annuities and temporary life annuities using commutation functions with and without deferment. **CO6:** Students will be able to calculate and analyze present values of assurance benefits and net level annual premiums for various assurance plans using commutation functions.		**U, Ap** **Ap, An**

PRACTICALS BASED ON COURSE ELEMENTS OF ACTUARIAL SCIENCE

1.	Mortality tables 1
2.	Mortality tables 2
3.	Annuities 1
4.	Annuities 2
5.	Life annuities
6.	Assurance benefits

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJP313	**<u>ELEMENTS OF ACTUARIAL SCIENCE</u>**	
CO1: Students will be able to solve and analyze numerical problems on mortality rates, force of mortality, expectation of life, and annuities certain for standard mortality tables. **CO2:** Students will be able to compute and evaluate numerical problems on life annuities, assurance benefits, net premiums, and office premiums using commutation functions.		**Ap, An** **An, E**

REFERENCES:

1. Dixit S.P., Modi C.S.&Joshi R.V.(1991). *Mathematical Basis of Life Assurance*, First edition (Reprint): Insurance Institute of India.
2. Gupta S. C. &. Kapoor V. K. (2014). *Fundamentals of Applied Statistics,* Fourth edition: Sultan Chand& Sons.
3. Neill A. (1977). *Life Contingencies,* First edition: Heineman educational books, London

ELECTIVE 1

Objectives:

- To appreciate role of Statistics in Biology.
- To understand need, ethics and norms of clinical trials.

Course Code	Title		Credits
SIUSTEL311	**<u>BIOSTATISTICS</u>**		**3**
Unit I : EPIDEMIC MODELS The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model with and without removals, Host Vector model, Carrier model. Chain binomial models. Reed - Frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of ‘p’ and its asymptotic variance for households of sizes up to four.			**1**
Unit II: BIOASSAYS Meaning and scope of bioassays. Relative potency. Direct assays. Fieller’s theorem. Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit analysis. Indirect assays. Dose-response relationship. Condition of similarity and Monotony. Linearizing transformations. Parallel line assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency.			**1**
Unit III: CLINICAL TRIALS AND BIOEQUIVALENCE Introduction to clinical trials: The need and ethics of clinical trials. Common terminology used in clinical trials. Over view of phases (I-IV) Study Protocol, Case record/Report form, Blinding (Single/Double) Randomized controlled (Placebo/Active controlled), Study Designs (Parallel, Cross Over). Types of Trials: Inferiority, Superiority and Equivalence, Multi-centric Trial. Inclusion/Exclusion Criteria. Statistical tools: Analysis of Parallel Design using Analysis of Variance. Concept of odds ratio. Sample size estimation. Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmakokinetic (PK) parameters C_{max}, AUC_t, $AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}. Estimation of PK parameters using ‘time vs. concentration’ profiles. Designs in Bioequivalence: Parallel, Cross over (Concept only). Advantages of Crossover design over Parallel design. Analysis of Parallel design using logarithmic transformation (Summary statistics, ANOVA and 90% confidence interval). Confidence Interval approach to establish bioequivalence (80/125 rule).			**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTEL311	**ELEMENTS OF ACTUARIAL SCIENCE**	
Unit I: EPIDEMIC MODELS **CO1:** Students will be able to define and explain features of epidemic spread and interpret deterministic, host-vector, carrier, and chain binomial models for epidemic processes. **CO2:** Students will be able to describe and compute maximum likelihood estimator of 'p' and its asymptotic variance using Reed-Frost and Greenwood models for household sizes.		**R, U** **U, Ap**
Unit II: BIOASSAYS **CO3:** Students will be able to explain and calculate relative potency, ED50, LD50, and apply Fieller's theorem and probit analysis for quantal response assays. **CO4:** Students will be able to implement and analyze parallel line assays including symmetrical (2,2) and (3,3) designs, validity tests using orthogonal contrasts, and estimate relative potency with confidence intervals.		**U, Ap** **Ap, An**
Unit III: CLINICAL TRIALS AND BIOEQUIVALENCE **CO5:** Students will be able to define and explain the phases, ethics, terminology, and study designs including randomized controlled trials, blinding, and inclusion/exclusion criteria in clinical trials. **CO6:** Students will be able to describe and compute pharmacokinetic parameters, apply logarithmic transformation, and establish bioequivalence using the 80/125 confidence interval rule.		**R, U** **U, Ap**

PRACTICALS BASED ON ELECTIVE COURSE BIOSTATISTICS

1. Epidemic models
2. Direct and Indirect Assays
3. Parallel line Assay
4. Clinical Trials
5. Bioequivalence

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTELP311	**BIOSTATISTICS**	
CO1: Students will be able to solve and analyze numerical problems on epidemic model parameters, MLE of infection probability, ED50, LD50, and probit analysis for standard datasets. **CO2:** Students will be able to compute and evaluate numerical problems on parallel line		**Ap, An** **An, E**

assay validity, PK parameter estimation, ANOVA for parallel design, and bioequivalence confidence intervals.	

REFERENCES:

2. Bailey N.T.J. (1975). *The Mathematical theory of infectious diseases,* Second edition: Charles Griffin and Co. London.
3. Bolton S. & Bon C. (2009). *Pharmaceutical Statistics*, Fifth edition: Marcel Dekker Inc.
4. Das M.N &Giri N.C.(1986). *Design and Analysis of Experiments,* Second edition: Wiley Eastern
5. Finney D.J. (1964). *Statistical Methods in Biological Assays*, First edition: Charles Griffin and Co. London
6. Fleiss J.L. (1999). *The Design and Analysis of Clinical Experiments*. Second edition: Wiley and Sons
7. Friedman L. M., Furburg C. D. ,Demets D. L.(2015). *Fundamentals of Clinical Trials*. Fifth edition: Springer Verlag.
8. Shein-Chung-Chow:(2008)*Design and Analysis of Bioavailability & Bioequivalence studies*, Third Edition: Chapman & Hall/CRC Biostatistics series.
9. Wayne D. W. (2013). *Biostatistics- A Foundation for Analysis in the Health Sciences*,Tenth Edition: Wiley Series in Probability and Statistics.
10. Zar Jerrold H. (2013). *Biostatistical Analysis,* Fifth edition: Pearson's education.

ELECTIVE 2

Objectives:

- To understand typical industry problems like transportation, assignment etc.
- To learn MS Excel to solve problems related to optimization.

Course Code	Title	Credits
SIUSTEL312	**OPERATIONS RESEARCH TECHNIQUES-I**	**3**
Unit I: LINEAR PROGRAMMING PROBLEM Mathematical Formulation: Maximization & Minimization. Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. Graphical Solution for problems with two variables. Simplex method of solving problems with two or more variables. Big M method. Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions of Primal and Dual. Economic interpretation of Dual.		**1**
Unit II: TRANSPORTATION PROBLEM Mathematical Formulation, Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization, Prohibited route type.		**1**
Unit III: ASSIGNMENT PROBLEM & SEQUENCING PROBLEM Assignment: Mathematical Formulation. Solution by Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type, Restricted (prohibited) route. Travelling Salesman Problem. Sequencing Problem: Processing n Jobs through 2 and 3 Machines & 2 Jobs through m Machines.		**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTEL311	**OPERATIONS RESEARCH TECHNIQUES I**	**3 Credits**
UNIT I: LINEAR PROGRAMMING PROBLEM **CO1:** Students will be able to define feasible solution, basic feasible solution, and optimal solution and describe the concept of duality and its economic interpretation in a linear programming problem. **CO2:** Students will be able to formulate maximization and minimization LPPs from problem statements and apply the graphical method, Simplex method, and Big M method to obtain optimal solutions and use duality to solve LPPs.		**R, U** **U, Ap**
UNIT II: TRANSPORTATION PROBLEM **CO3:** Students will be able to state the mathematical formulation of the transportation problem and distinguish between balanced and unbalanced, minimization and maximization, and prohibited route variants. **CO4:** Students will be able to apply the North-West Corner Rule, Matrix Minima, and Vogel's Approximation Method to find the initial basic feasible solution and use the MODI method to obtain the optimal solution.		**R, U** **U, Ap**
UNIT III: ASSIGNMENT PROBLEM & SEQUENCING **CO5:** Students will be able to state the mathematical formulation of the assignment problem and describe the sequencing problem for n jobs through 2 and 3 machines and 2 jobs through m machines. **CO6:** Students will be able to apply the Hungarian method to solve assignment problems including unbalanced, maximization, and restricted variants and solve the Travelling Salesman Problem and sequencing problems to minimize total elapsed time.		**R, U** **U, Ap**

PRACTICALS BASED ON OPERATIONS RESEARCH TECHNIQUES I

1. Formulation and Graphical Solution of L.P.P.
2. Simplex Method.
3. Duality.
4. Transportation.
5. Assignment.
6. Sequencing.

Course Code	Title	BLOOMS LEVEL
SIUSTELP311	**PRACTICAL ON OPERATIONS RESEARCH**	
CO1: Students will be able to solve LPP numerical using graphical, Simplex, and Big M methods and construct the dual of a given primal problem to verify the relationship between their optimal solutions.		**Ap, An**
CO2: Students will be able to determine the optimal solution for transportation problems using different methods across all variants and evaluate assignment and sequencing problems to identify minimum cost or time solutions using Hungarian method and sequencing algorithms.		**E, C**

<u>REFERENCES</u>:

1. Bronson R. (1997). *Schaum Series book in Operations Research.* Second edition: Tata McGrawHill Publishing Company Ltd.

2. Kantiswaroop&Gupta M. (2010). *Operations Research*, Twelfth Edition: S Chand & Sons.

3. Sasieni M., Yaspan A.&Friedman L. (1959).*Operations Research; Methods and Problems*: JohnWiley & Sons.

4. Sharma J. K. (1989). *Mathematical Models in Operations Research*:Tata McGraw Hill PublishingCo. Ltd.

5. Sharma J.K. (2001). *Quantitative Techniques for Managerial Decisions*: MacMillan India Ltd.

6. Sharma S.D. *Operations Research*. Eleventh Edition: KedarNath Ram Nath& Company.

7. TahaH. A.(2010). *Operations Research*. Ninth Edition: Prentice Hall of India.

8. Wagner H. M. (1970). *Principles of Operations Research with Applications to Management Decisions,* Second Edition : Prentice Hall of India Ltd.

TYBSC SYLLABUS UNDER NEP

SEMESTER VI

MAJOR 1

Objectives

- To acquire in-depth knowledge of probability theory.
- To understand significance of correlation using bivariate normal distribution.

Course Code	**Title**	**Credits**
SIUSTMJ321	**<u>PROBABILITY AND DISTRIBUTION THEORY</u>**	**3**
Unit I : PROBABILITY Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. Mathematical, Statistical, Axiomatic and Subjective probability. Sub populations and partitions. Probabilities based on Maxwell Boltzmann, Bose Einstein and Fermi Dirac Statistics. Ordered samples and runs. Addition Theorem for two & three events. Theorems on Probability of realization of : At least one, Exactly m, At least m of N events A_1, A_2, $A_3 \ldots A_N$. Matching and Guessing problems. Conditional Probability: Multiplication Theorem for two and three events. Independence of two and three events - complete and pair wise. Polya's urn model Bayes' theorem.		**1**
Unit II: JOINT MOMENT GENERATING FUNCTION, TRINOMIAL AND MULTINOMIAL DISTRIBUTION Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary condition for independence of two random variables. Concept and definition of Multivariate MGF. Trinomial distribution**:** Definition of joint probability distribution of (X, Y). Joint moment generating function, moments $\square_{rs}$ where r=0, 1, 2 and s=0, 1, 2. Marginal &Conditional distributions. Means & Variances. Correlation coefficient between (X, Y). Distribution of the Sum X+Y. Extension to Multinomial distribution with parameters (n, p_1, p_2, $\ldots p_{k-1}$) where p_1+ p_2,+…p_{k-1}+ p_k= 1. Expression for joint MGF. Derivation of: joint probability distribution of (X_i, X_j). Conditional probability distribution of X_i given $X_j = x_j$		**1**

Unit III: BIVARIATE NORMAL DISTRIBUTION Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. Marginal & Conditional distributions. Means & Variances. Correlation coefficient between the random variables. Necessary and sufficient condition for the independence of X and Y. Distribution of aX+bY, where 'a' and 'b' are constants. Distribution of sample correlation coefficient. Testing the significance of a correlation coefficient. Fisher's z – transformation. Tests for $H_0:\rho = 0$, $H_0: \rho = \rho_0$ & $H_0: \rho_1 = \rho_2$ Confidence interval for ρ.	**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ321	**PROBABILITY AND DISTRIBUTION THEORY**	**3 Credits**
UNIT I: PROBABILITY **CO1:** Students will be able to define and explain basic probability definitions, axioms, addition theorem, conditional probability, independence of events, and Bayes' theorem. **CO2:** Students will be able to interpret and compute probabilities based on Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics, and solve matching, guessing, and Polya's urn model problems.		**R, U** **U, Ap**
UNIT II: JOINT MOMENT GENERATING FUNCTION, TRINOMIAL AND MULTINOMIAL DISTRIBUTION **CO3:** Students will be able to define and explain MGF of two random variables, properties of Trinomial and Multinomial distributions, and conditions for independence of random variables. **CO4:** Students will be able to derive and compute joint MGF, moments, marginal and conditional distributions, correlation coefficient, and distribution of X+Y for Trinomial and Multinomial distributions.		**R, U** **U, Ap**
UNIT III: BIVARIATE NORMAL DISTRIBUTION **CO5:** Students will be able to explain and derive joint MGF, moments, marginal and conditional distributions, and independence conditions for Bivariate Normal Distribution. **CO6:** Students will be able to apply and interpret Fisher's Z-transformation and perform hypothesis tests for correlation coefficient including confidence interval estimation for ρ.		**U, Ap** **Ap, An**

PRACTICALS BASED ON COURSE PROBABILITY AND DISTRIBUTION THEORY

1. Probability-1
2. Probability -2
3. Probability -3
4. Joint Moment Generating function
5. Trinomial &Multinomial Distribution
6. Bivariate Normal Distribution
7. Tests for correlation and Interval estimation

Course Code	Title	BLOOMS LEVEL
SIUSTMJP321	**PRACTICAL ON PROBABILITY AND DISTRIBUTION THEORY**	
CO1: Students will be able to solve and analyze numerical problems on probability theorems, conditional probability, Bayes' theorem, and statistical distributions including Trinomial and Multinomial distributions.		**Ap, An**
CO2: Students will be able to compute and evaluate numerical problems on Bivariate Normal distribution, moments, correlation coefficient, Fisher's Z-transformation, and hypothesis testing for ρ.		**An, E**

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1. Biswas S.(1991). *Topics in Statistical Methodology*,First edition: Wiley Eastern Ltd.
2. ChandraT.K.&ChatterjeeD.(2005). *A First Course in Probability*,Third Edition: Narosa Publishing House.
3. Feller W. (1968). *An introduction to probability theory and it's applications,* Volume 1, Third edition :Wiley Eastern Limited.
4. Gupta S C & KapoorV K. (2014). *Fundamentals of Mathematical Statistics*, Eleventh edition, Sultan Chand & Sons.
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7. KapurJ. N.&Saxena H. C.(2010). *Mathematical Statistics*, Fifteenth edition: S. Chand and Company.
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MAJOR 2

Objectives

- To study order statistics and generating functions useful in research
- To learn stochastic processes to understand its application in queuing theory

Course Code	Title	Credits
SIUSTMJ322	**DISTRIBUTION THEORY AND STOCHASTIC PROCESSES**	**3**
	Unit I : ORDER STATISTICS Definition of Order Statistics based on a random sample. Derivation of: Cumulative distribution function of r^{th} order statistic, Probability density functions of the r^{th} order statistic, Joint Probability density function of the r^{th} and the s^{th} order statistic ($r < s$),Joint Probability density function of all n ordered statistics, Probability density function of Median (in the case of odd sample sizes) and Range.	**1**
	Unit II: STOCHASTIC PROCESSES Definition of stochastic process. Postulates and difference differential equations for: Pure birth process, Poisson process with initially 'a' members, for a =0 and a >0, Yule-Furry process, Pure death process, Death process with $\mu_n=\mu$, Death process with $\mu_n=n\mu$, Birth and death process, Linear growth model. Derivation of $P_n(t)$, mean and variance where ever applicable.	**1**
	Unit III: QUEUING THEORY Basic elements of the Queuing model. Roles of the Poisson and Exponential distributions. Derivation of Steady state probabilities for birth and death process. Steady state probabilities and various average characteristics for the following models: (M/M/1) : (GD/ ∞ /∞), (M/M/1) : (GD/ N /∞), (M/M/c) : (GD/∞/∞), (M/M/c) : (GD/ N /∞), (M/M/∞) : (GD/ ∞ /∞), (M/M/R) : (GD/ k /k)	**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ322	**DISTRIBUTION THEORY AND STOCHASTIC PROCESSES**	**3 Credits**
	UNIT I: ORDER STATISTICS **CO1:** Students will be able to define and explain order statistics and derive the CDF and PDF of the rth order statistic for a random sample. **CO2:** Students will be able to derive and compute joint PDF of rth and sth order statistics, all n ordered statistics, and PDF of median and range.	**R, U** **U, Ap**
	UNIT II: STOCHASTIC PROCESSES **CO3:** Students will be able to define and explain stochastic processes and interpret postulates and difference differential equations for pure birth, death, and birth-death processes. **CO4:** Students will be able to derive and compute Pn(t), mean and variance for Poisson process, Yule-Furry process, linear growth model, and related stochastic models..	**R, U** **U, Ap**
	UNIT III: QUEUEING THEORY **CO5:** Students will be able to define and explain basic elements of queuing models and derive steady state probabilities for birth and death process using Poisson and Exponential distributions. **CO6:** Students will be able to derive and compute steady state probabilities and average characteristics for queuing models.	**R, U** **U, Ap**

PRACTICALS BASED ON COURSE STOCHASTIC PROCESSES

1.	Order Statistics – 1
2.	Order statistics – 2
3.	Stochastic Processes
4.	Queuing Theory -1
5.	Queuing Theory -2

Course Code	Title	BLOOMS LEVEL
SIUSTMJP322	**PRACTICAL ON DISTRIBUTION THEORY AND STOCHASTIC PROCESSES**	
CO1: Students will be able to solve and analyze numerical problems on order statistics, PDF and CDF derivations, and stochastic process parameters including mean and variance.		**Ap, An**
CO2: Students will be able to compute and evaluate numerical problems on steady state probabilities and average characteristics for standard queuing models.		**An, E**

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1. Biswas S.(1991). *Topics in Statistical Methodology* ,First edition: Wiley Eastern Ltd.
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8. Mood A. M., Graybill F. A.&Boyes D. C. (1974).*Introduction to the theory of Statistics*, Third edition, McGraw- Hill Series.
9. Taha H.A.(2010). *Operations Research: An introduction*, Ninth edition: Prentice Hall of India Pvt. Ltd.

MAJOR III

Objectives:

- To study testing statistical hypotheses for fixed and variable sample sizes
- To understand applications non parametric tests used in social sciences

Course Code	Title	Credits
SIUSTMJ323	**<u>TESTING OF HYPOTHESES</u>**	3
Unit I : MOST POWERFUL TESTS : UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS Problem of testing of hypothesis. Definitions of Simple hypothesis, Composite hypothesis, Null Hypothesis, Alternative Hypothesis, Test of hypothesis, Critical region, Type I and Type II errors, Level of significance, p-value, size of the test, Power of the test, Power function of a test, Power curve. Definition of most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Definition, Existence and Construction of uniformly most powerful (UMP) test. Likelihood ratio principle. Definition of test statistic and its asymptotic distribution (statement only).		1
Unit II: SEQUENTIAL PROBABILITY RATIO TESTS Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size test procedure. Definition of Wald's SPRT of strength (α, β).		1
Unit III: NON-PARAMETRIC TESTS Need for non-parametric tests. Distinction between a parametric and a non-parametric test .Concept of a distribution free statistic. Single sample and two sample Nonparametric tests: Sign test, Wilcoxon's signed rank test, Run test, Mann–Whitney test, Median test, Kruskal Wallis test, Friedman test, Fisher's exact test. Assumptions, justification of the test procedure for small & large samples.		1

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTMJ323	<u>**TESTING OF HYPOTHESES**</u>	**3 Credits**
UNIT I: MOST POWERFUL TESTS : UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS **CO1:** Students will be able to define and explain key testing concepts including null and alternative hypothesis, critical region, Type I and II errors, power function, and p-value. **CO2:** Students will be able to interpret and construct Most Powerful tests using Neyman-Pearson Lemma and derive UMP tests and Likelihood Ratio tests for standard distributions.		**R, U** **U, Ap**
UNIT II: SEQUENTIAL PROBABILITY RATIO TESTS **CO3:** Students will be able to define and explain Wald's SPRT of strength (α, β) and compare sequential test procedure with fixed sample size test procedure. **CO4:** Students will be able to describe and apply SPRT for testing simple null hypothesis against simple alternative hypothesis for standard distributions.		**R, U** **U, Ap**
UNIT III: NON-PARAMETRIC TESTS **CO5:** Students will be able to define and distinguish between parametric and non-parametric tests and explain the concept of distribution free statistics. **CO6:** Students will be able to identify and apply appropriate non-parametric tests including Sign test, Wilcoxon, Mann-Whitney, Kruskal-Wallis, Friedman, and Fisher's exact test for small and large samples.		**R, U** **U, Ap**

PRACTICALS BASED ON COURSE TESTING OF HYPOTHESES

1. Testing of Hypothesis 1
2. Testing of Hypothesis 2
3. Likelihood Ratio Tests
4. SPRT
5. Non Parametric test 1
6. Non Parametric test 2

Course Code	Title	BLOOMS LEVEL
SIUSTMJP323	**PRACTICAL ON TESTING OF HYPOTHESES**	
CO1: Students will be able to solve and analyze numerical problems on Neyman-Pearson Lemma, UMP tests, Likelihood Ratio tests, and SPRT for standard hypothesis testing situations.		**Ap, An**
CO2: Students will be able to compute and evaluate numerical problems on non-parametric tests including Sign test, Wilcoxon, Mann-Whitney, Kruskal-Wallis, and Friedman tests for given datasets.		**An, E**

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3. Daniel W.W..(2000)*Applied Non Parametric Statistics* Second edition Boston-Houghton Mifflin Company
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ELECTIVE 1

Objectives:

- To carry out exploratory analysis of a time series.
- Able to identify different components of a time series.
- Analyze different time series processes.

Course Code	Title	Credits
SIUSTEL321	TIME SERIES ANALYSIS	3
Unit I: INTRODUCTION TO TIME SERIES Definition of time series. Real life examples of time series. Its components. Models of time series. Exponential Smoothing method. Estimation of trend by: Freehand curve, Method of semi averages, Method of Moving averages, Method of least squares (linear trend only). Merits and demerits of these methods. Estimation of seasonal component by: Method of simple averages, Ratio to moving average method, Ratio to trend method.		1
Unit II: STATIONARITY AND AUTOCORRELATION Stationary time series. Auto-covariance and auto-correlation functions, properties of auto-correlation function of a stationary process. Mean, auto-covariance and autocorrelation functions of stationary process. Tests of randomness, tests for trend, seasonality, Gaussian process. Filters (Difference, linear and Moving average), White Noise process, Higher order exponential smoothing. Holt linear trend, Holt –Winters smoothing(only for additive models). Forecasting based on smoothing.		1
Unit III: AUTOREGRESSIVE AND MOVING AVERAGE PROCESSES General linear process, Auto regressive (AR) and Moving average (MA) processes, autocorrelation and partial autocorrelation Introduction to ARMA and ARIMA processes		1

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTEL321	**<u>TIME SERIES ANALYSIS</u>**	**3 Credits**
UNIT I: INTRODUCTION TO TIME SERIES **CO1:** Students will be able to define and explain components and models of time series and interpret trend estimation methods including moving averages, least squares, and exponential smoothing. **CO2:** Students will be able to describe and compute seasonal components using simple averages, ratio to moving average, and ratio to trend methods with their merits and demerits.		**R, U** **U, Ap**

UNIT II: STATIONARITY AND AUTOCORRELATION **CO3:** Students will be able to explain and compute auto-covariance, autocorrelation functions, and apply tests for randomness, trend, and seasonality for stationary time series. **CO4:** Students will be able to implement and evaluate Holt linear trend, Holt-Winters smoothing, filters, and white noise process for forecasting using smoothing methods.	**U, Ap** **Ap, An**
UNIT III: AUTOREGRESSIVE AND MOVING AVERAGE PROCESSES **CO5:** Students will be able to explain and derive autocorrelation and partial autocorrelation functions for AR and MA processes under the general linear process framework. **CO6:** Students will be able to identify and apply appropriate ARMA and ARIMA models for modeling and forecasting standard time series data.	**U, Ap** **Ap, An**

PRACTICALS BASED ON ELECTIVE COURSE TIME SERIES ANALYSIS

1. Estimation of trend and seasonality.
2. Stationary time series.
3. Autocovariance and Autocorrelation
4. Holt and Winters Smoothing.
5. AR and MA Processes.

Course Code	Title	BLOOMS LEVEL
SIUSTELP321	**PRACTICAL ON TIME SERIES ANALYSIS**	
CO1: Students will be able to solve and analyze numerical problems on trend estimation, seasonal component calculation, autocorrelation functions, and exponential smoothing methods. **CO2:** Students will be able to compute and evaluate numerical problems on AR, MA, ARMA, and ARIMA processes including parameter estimation and forecasting for standard time series datasets.		**Ap, An** **An, E**

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- Shumway, R. H. and Stoffer, D. S. (2010): Time Series Analysis & its Applications, Springer.
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ELECTIVE 2

Objectives:

- To comprehend knowledge of industry problems such as inventory, replacement

Course Code	Title	Credits
SIUSTEL322	**OPERATIONS RESEARCH TECHNIQUES-II**	**3**
Unit I:INVENTORY CONTROL Introduction to Inventory Problem Deterministic Models: Single item static EOQ models for Constant rate of demand with instantaneous replenishment, with and without shortages. Constant rate of demand with uniform rate of replenishment, with and without shortages. Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks. Price break model. Probabilistic models: Single period with Instantaneous demand (discrete and continuous) without setup cost. Uniform demand (discrete and continuous) without set up cost.		**1**
Unit II: REPLACEMENT Replacement of items that deteriorate with time and value of money remains constant & changes with time. Replacement of items that fail completely: Individual replacement and Group replacement policies.		**1**
Unit III: SIMULATION Scope of simulation applications. Types of simulation. Monte Carlo Technique of Simulation. Elements of discrete event simulation. Generation of random numbers. Sampling from probability distribution. Inverse method. Generation of random observations from standard distributions. Simulation techniques applied to inventory and Queuing models.		**1**

Course Code	COURSE OUTCOMES	BLOOMS LEVEL
SIUSTEL322	**OPERATIONS RESEARCH TECHNIUES- II**	**3 Credits**
UNIT I: INVENTORY CONTROL **CO1:** Students will be able to define and explain inventory problems and interpret deterministic EOQ models for constant demand with and without shortages and price breaks. **CO2:** Students will be able to describe and compute optimal inventory policies for probabilistic single period models with instantaneous and uniform demand for discrete and continuous cases.		**R, U** **U, Ap**

UNIT II: REPLACEMENT **CO3:** Students will be able to define and explain replacement policies for deteriorating items with constant and changing value of money over time. **CO4:** Students will be able to describe and determine optimal individual and group replacement policies for items that fail completely using standard replacement models.	**R, U** **U, Ap**
UNIT III: SIMULATION **CO5:** Students will be able to define and explain types of simulation, Monte Carlo technique, elements of discrete event simulation, and methods of random number generation. **CO6:** Students will be able to describe and apply inverse method and simulation techniques to generate random observations and simulate inventory and queuing models.	**R, U** **U, Ap**

PRACTICALS BASED ON COURSE OPERATIONS RESEARCH TECHNIQUES II

1.	Inventory1
2.	Inventory2
3.	Replacement
4.	Simulation I
5.	Simulation II

Course Code	Title	BLOOMS LEVEL
SIUSTELP322	**PRACTICAL ON OPERATIONS RESEARCH TECHNIQUES-II**	
CO1: Students will be able to solve and analyze numerical problems on EOQ models, price break models, probabilistic inventory models, and replacement policies for standard cases. **CO2:** Students will be able to compute and evaluate numerical problems on Monte Carlo simulation, random number generation, and simulation of inventory and queuing models for given datasets.		**Ap, An** **An, E**

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