Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the T.Y.B.Sc.

Program: B.Sc. STATISTICS

Program Code: RJSUSTA

(CBCS 2021-22)

DISTRIBUTION OF TOPICS AND CREDITS

T.Y.B.Sc. STATISTICS SEMESTER V

Course	Nomenclature	Credits	Topics
RJSUSTA501	Probability and Distribution Theory	2.5	1. Probability-I 2. Probability-II 3. Joint Moment Generating Function, Trinomial & Multinomial Distribution 4. Order Statistics
RJSUSTA502	Theory of Estimation	2.5	5. Point Estimation & Properties of Estimators 6. Methods of Estimation 7. Bayesian Estimation Method & Interval Estimation 8. Introduction to Linear Models
RJSUSTA503	Biostatistics	2.5	9. Epidemic Models 10. Bioassay 11. Clinical Trials 12. Clinical Trials and Bioequivalence

RJSUSTA504	Regression Analysis using R Software	2.5	13. Fundamentals of R 14. Simple Linear Regression Model 15. Multiple Linear Regression Model 16. Validity Of Assumptions
RJSUSTAP501	Practicals of Course RJSUSTA501 + Course RJSUSTA502	03	
RJSUSTAP502	Practicals of Course RJSUSTA503 + Course RJSUSTA504	03	

T.Y.B.Sc. STATISTICS SEMESTER VI

Course	Nomenclature	Credits	Topics
RJSUSTA601	Distribution Theory and Stochastic Processes	2.5	1. Bivariate Normal Distribution 2. Generating Functions 3. Stochastic Processes 4. Queueing Theory
RJSUSTA602	Testing of Hypothesis	2.5	5. Most Powerful Tests 6. Uniformly Most Powerful & Likelihood Ratio Tests

			7. Sequential Probability Ratio Test (SPRT) 8. Non-Parametric Tests
RJSUSTA603	Operations Research Techniques	2.5	9. Linear Programming Problem 10. Inventory Control 11. Replacement Theory 12. Simulation And Reliability
RJSUSTA604	Elements of Actuarial Science	2.5	13. Mortality Tables 14. Compound Interest And Annuities Certain 15. Life Annuities 16. Assurance Benefits
RJSUSTAP601	Practicals of Course RJSUSTA601 + Course RJSUSTA602	03	
RJSUSTAP602	Practicals of Course RJSUSTA603 + Course RJSUSTA604	03	

SEMESTER V (THEORY)		L	Cr
Paper-I: Probability and Distribution Theory	**Paper Code: RJSUSTA501**	60	2.5
UNIT I		15	
PROBABILITY-I			
1	Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events.		
2	Mathematical, Statistical, Axiomatic and Subjective probability.		
3	Sub populations and partitions. Derivation of (a) Ar,n : Number of distinguishable distributions of putting r indistinguishable balls in n cells; (b) Number of distinguishable distributions of putting r indistinguishable balls in n cells such that no cell is empty.		
4	Ordered samples and runs.		
5	Probabilities based on a) Maxwell Boltzmann, Bose Einstein and Fermi Dirac Statistics.		
6	Addition Theorem for (a) two (b) three events.		
UNIT II		15	
PROBABILITY II			
1	Theorems on Probability of realization of: (a) At least one (b) Exactly m (c) At least m of N events A_1, A_2, A_3…A_N. Matching and Guessing problems.		

2	Conditional Probability: Multiplication Theorem for two, three events. Independence of two/three events - complete and pair wise		
3	Bayes' theorem.		
UNIT III		15	
JOINT MOMENT GENERATING FUNCTION, TRINOMIAL AND MULTINOMIAL DISTRIBUTION			
1	Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Multivariate MGF.		
2	Trinomial distribution: Definition of joint probability distribution of (X, Y). Joint moment generating function, moments μ_{rs} where r=0, 1, 2 and s = 0, 1, 2. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y). Distribution of the Sum X+Y.		
3	Extension to Multinomial distribution with parameters (n, p1, p2,…pk-1) where p1+ p2,+…pk-1+ pk = 1. Expression for joint MGF. Derivation of: joint probability distribution of (Xi, Xj). Conditional probability distribution of Xi given Xj =xj.		
UNIT IV		15	
ORDER STATISTICS			
1	Definition of Order Statistics based on a random sample.		
2	Derivation of: (a) Cumulative distribution function of rth order statistics. (b) Probability density function of the rth order statistics. (c) Joint Probability density function of the rth and the sth order statistics (r<s) (d) Joint Probability density function of all n ordered statistics.		

3	Probability density function of Median (in the case of odd sample sizes) and Range for Uniform and Exponential distributions.		

T.Y.B.Sc	Semester V Theory
RJSUSTAP501 Paper I Probability and Distribution Theory	Course Outcomes 5.1 : This course will provide the students with knowledge 1. about the basics of probability and its application. 2. ability to handle transformed random variables and derive associated distributions. 3. of importance of multinomial distribution. 4. about order statistics and its applications. Learning outcomes: After going through this course, the students will ➢ strengthen the concepts in mathematical statistics. ➢ improve the skills of probability to use in the Data Science field. ➢ increase the ability to solve real life examples of probabilities.

SEMESTER V (THEORY)		L	Cr
Paper-II: Theory of Estimation	**Paper Code: RJSUSTA502**	60	2.5
UNIT I		15	
POINT ESTIMATION AND PROPERTIES OF ESTIMATOR- I			
1	Unbiasedness: Definition of an unbiased estimator, biased estimator, positive and negative bias, illustrations and examples (these should include unbiased and biased estimators for the same parameters). Proofs of the following results regarding unbiased estimators. (a) Two distinct unbiased estimators of $\varphi(\theta)$ give rise to infinitely many unbiased estimators. (b) If T is an unbiased estimator of θ , then $\varphi(T)$ is unbiased estimator of $\varphi(\theta)$ provided $\varphi(.)$ is a linear function.		
2	Consistency: Definition of Consistency Sufficient condition for consistency, proof & Illustrate.		
3	Sufficiency: Concept and definition of Sufficiency, Neyman Factorization Theorem (without proof). Exponential family of probability distributions and Sufficient statistics.		
4	Relative efficiency of an estimator. Illustrative example.		
5	Minimum variance unbiased estimator (MVUE) and Cramer Rao Inequality: Definition of MVUE, Uniqueness property of MVUE (proof). Fisher's information function Regularity conditions, Statement and proof of Cramer-Rao inequality, Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. Condition when equality is attained in Cramer Rao Inequality and its use in finding MV.		
UNIT II		15	

	METHODS OF POINT ESTIMATION		
1	Method of Maximum Likelihood Estimation (M.L.E.), Definition of likelihood as a function of unknown parameter, for a random sample from i) discrete distribution ii) continuous distribution. Distinction between likelihood function and joint p.d.f. / p.m.f. Derivation of Maximum Likelihood Estimator (M.L.E.) for parameters of standard distributions (case of one and two unknown parameters). Properties of M.L.E (without proof).		
2	Method of Moments, Derivation of moment estimators for standard distributions (case of one and two unknown parameters). Illustrations of situations where M.L.E. and Moment Estimators are distinct and their comparison using Mean Square Error.		
3	Method of Minimum Chi-square and Modified Minimum Chi-square.		
	UNIT III	15	
	BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL		
1	Bayesian Estimation: Prior distribution, Posterior distribution, Types of Loss function : Squared error Loss function, Absolute error Loss function (AELF), Bayes' risk, Bayes' method of finding Point estimator (assuming SELF) Examples : (a) Binomial- Beta (b) Poisson- Gamma (c) Gamma-Gamma (d) Normal-Normal.		
2	Interval Estimation: Concept of confidence interval & confidence limits. Definition of Pivotal quantity and its use in obtaining confidence limits. Derivation of 100(1-α) % equal tailed confidence interval for : (a)The population mean : μ_1, $\mu_1-\mu_2$ (population variance known/ unknown) (b) the population variance: $\sigma^2, \frac{{\sigma_1}^2}{{\sigma_2}^2}$(Normal distribution).		
3	Confidence interval for the parameters of Binomial, Poisson and Exponential distributions.		

	UNIT IV		
	INTRODUCTION TO LINEAR MODELS	15	
1	Explanation of General Linear Model of full rank with assumptions. Model Y= Xβ + e , e ~ $N(0, I\sigma^2)$		
2	Derivation of: 1) Least squares estimator of β 2) E(β) 3) V(β) .		
3	Gauss Markoff theorem for full rank Model: Y = Xβ + e.		
4	Derivation of: 1) E(l'β) 2) V(l'β)		
5	Confidence interval for l'β when σ^2 is known.		
6	Confidence interval of β when σ^2 is known.		

T.Y.B.Sc	Semester V Theory
RJSUSTA502 Paper II Theory of Estimation	Course Outcomes 5.2 : This course will provide the students with knowledge to 1. understand the difference between the classical and Bayesian approach to estimation; describe the notions of estimator bias, variance, and efficiency; and describe the notion of sufficient statistics and its meaning in minimum variance unbiased (MVU) estimation. 2. develop system models and parameter estimation problems and derive corresponding Cramer-Rao lower bounds and sufficient statistics. Prove optimality of estimators.

	3. apply appropriate estimators – including linear least squares, maximum likelihood and method of moments estimators – after considering estimation accuracy and complexity requirements. Learning outcomes: After going through this course, the students will get ➢ a fundamental understanding of parametric models for developing relevant inferences on associated parameters. ➢ knowledge of point and interval estimation procedures and different methods of point estimation. ➢ to knowledge of the Cramer-Rao Inequality, Rao Blackwell and Lehmann Scheffe theorems and their applications in obtaining Minimum Variance Unbiased and Minimum Variance Bound estimators.

SEMESTER V (THEORY)		L	Cr
Paper-III: Biostatistics	**Paper Code: RJSUSTA503**	60	2.5
UNIT I		15	
EPIDEMIC MODELS			
1	The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals, Carrier model.		
2	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 4.		
UNIT II		15	
BIOASSAYS			
1	Meaning and scope of bioassays. Relative potency. Direct assays. Point estimate and Interval estimate of relative potency, Fieller's theorem.		
2	Indirect assays. Dose-response relationship. Conditions 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.		
3	Quantal Response assays. Tolerance distribution. Median effective dose ED50 and Median lethal dose LD50. Probit and Logit analysis.		
UNIT III			

	CLINICAL TRIALS	15	
1	Introduction to clinical trials: The need and ethics of clinical trials. Common terminology used in clinical trials.		
2	Overview of phases (I-IV) , Introduction to ICH E9 guidelines, Study Protocol, Case record/Report form, Blinding (Single/Double) Randomized controlled (Placebo/Active controlled), Study Designs (Parallel, Cross Over).		
3	Types of Trials: Inferiority, Superiority and Equivalence, Multicentre Trial. Inclusion/Exclusion Criteria. Sample size estimation.		
	UNIT IV	15	
	CLINICAL TRIALS AND BIOEQUIVALENCE		
1	Statistical tools : Analysis of parallel Design using Analysis of Variance. Concept of odds ratio. Concept of Repeated Measures ANOVA. Survival analysis for estimating Median survival time, Kaplan-Meire approach for survival analysis.		
2	Bioequivalence: Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (P_K) parameters : Cmax, AUCt , AUC(0–∞), T_{max}, K_{el}, T_{half}. Estimation of PK parameters using `time vs. concentration' profiles.		
3	Designs in Bioequivalence: Parallel, Crossover (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).		

T.Y.B.Sc	Semester V Theory
RJSUSTA503 Paper III Biostatistics	Course Outcomes 5.3: The course is of applied nature and will provide the students acquire - 1. the basic idea of communicable diseases, different stages of epidemics and various models like Simple epidemic model, Career model and Chain binomial model. 2. knowledge of different types of Bioassay, estimation of relative potency and its confidence interval, direct assay and indirect assay, quantitative response assay and quantal response assay, effective dose and lethal dose, principles and conduct of clinical trial experiments with an overall view of Phase I-IV trials, various clinical trial designs commonly employed in practice. 3. benefits and risks associated with clinical trials, various terms related with clinical trials and blinding, phases, study designs. 4. Odds ratio, repeated measures, survival analysis, Kaplan Meire analysis, Pharmacokinetic parameters, Designs involved in Bioequivalence, 90% C.I 80 /125 rule.

	Learning outcomes: The students will be able ➢ to apply statistics to Biological sciences. ➢ to calculate no. of susceptibles, no. of infectives for large population, probability of spreading disease for small population, estimating probability of adequate contact to spread the disease, and its S.E. ➢ to compare old and new drugs in terms of relative potency. ➢ to handle the data to check the safety and efficacy of new drugs. ➢ to check whether formulation is bioequivalent.

SEMESTER V (THEORY)		**L**	**Cr**
Paper-IV: Regression Analysis using R software	**Paper Code: RJSUSTA504**	60	2.5
UNIT I		15	
FUNDAMENTALS OF R			
1	Introduction to R, features of R, installation of R, Starting and ending R session, getting help in R , Value assigning to variables. Basic Operations : +, -, *, ÷, ^, sqrt . Numerical functions : log 10, log , sort, max, unique, range, length, var, prod, sum, summary, dim, sort, etc . Data Types : Vector, list, matrices, array and data frame. Variable Type : logical, numeric, integer, complex, character and		

	factor. Data Processing : Data import and export, setting working directory, checking structure of data :Str(), Class(), Changing type of variable (for eg as.factor, as.numeric)		
2	Data Manipulation : Selecting random N rows, removing duplicate row(s), dropping a variable(s) , Renaming variable(s), subsetting data, creating a new variable(s), selecting of random fraction of row(s), appending of row(s) and column(s), simulation variable.		
3	Data Visualization using ggplot: Simple bar diagram, subdivided bar diagram, multiple bar diagram pie diagram, Box plot for one and more variables, histogram, frequency polygon, scatter plot eg plot().		
	UNIT II	15	
	SIMPLE LINEAR REGRESSION MODEL		
1	Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients for simple, Properties of least square estimators (without proof), Coefficient of determination R^2 and adjusted R^2. Procedure of testing a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients Data.		
2	Pre-processing: Detection and treatment of missing value(s)and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R. Polynomial Regression Models.		
	UNIT III	15	
	MULTIPLE LINEAR REGRESSION MODEL		

1	Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2. Procedure of testing a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients.		
2	Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R.		
	UNIT IV	15	
	VALIDITY OF ASSUMPTIONS		
1	Residual Diagnostics: Standardized residuals, Studentized residuals, residual plots, interpretation of four plots, interpretation output produced by plot command in R and corrective measures such as transformation of response variable, testing normality of data .		
2	Autocorrelation: Concept and detection using Durbin Watson Test, Interpretation of output produced by DW-test function in R, Heteroscedasticity: Concept and detection using Breusch –Pagan-Godfrey Test, Interpretation of output produced by bptest function in R.		
3	Multicollinearity: Concept and detection using i) R^2 and t-ratios ii) pairwise correlation between repressors iii) Variance Inflation Factor(VIF), Interpretation of output produced by mctest function in R, Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures.		

T.Y.B.Sc	Semester V Theory
RJSUSTA504 Paper IV Regression Analysis using R software	Course Outcomes 5.4 : This course will help students 1. to apply linear regression models in practice: identify situations where linear regression is appropriate; build and fit linear regression models with software; interpret estimates and diagnostic statistics; produce exploratory graphs. 2. to learn about the theory underlying point estimation, hypothesis and confidence intervals for linear regression models. Learning outcomes: The students will be able ➢ to develop the technique of model building using software. ➢ to understand how predictions can be made using regression models.

SEMESTER VI (THEORY)		L	Cr
Paper-I: Distribution theory and Stochastic Processes	**Paper Code: RJSUSTA601**	60	2.5
UNIT I		15	
BIVARIATE NORMAL DISTRIBUTION			
1	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. Their Means & Variances. Correlation coefficient between the random variables. Necessary and sufficient conditions for the independence of X and Y. Distribution of aX + bY, where 'a' and 'b' are constants.		
2	Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. Fisher's z – transformation. Tests for i) $H_0: \rho = \rho_0$ ii) $H_1: \rho_1 = \rho_2$. Confidence interval for ρ.		
UNIT II		15	
GENERATING FUNCTIONS			
1	Definitions of generating function and probability generating function. Expression for mean and variance in terms of generating functions. Definition of a convolution of two or more sequences. Generating function of a convolution. Generating functions of the standard discrete distributions. Relation between: i) Bernoulli and Binomial distributions ii) Geometric and Negative Binomial distributions in terms of convolutions.		

	UNIT III	15	
	STOCHASTIC PROCESSES		
1	Definition of stochastic process. Postulates and difference differential equations for : (i) Pure birth process (ii) Poisson process with initially 'a' members, for a =0 and a >0 (iii) Yule Furry process (iv)Pure death process (v) Death process with μ_n=μ (vi) Death process with μ_n= nμ (vii) Birth and death process (viii) Linear growth model. Derivation of Pn (t), mean and variance wherever applicable.		
	UNIT IV	15	
	QUEUEING THEORY		
1	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: (i) (M/M/1) : (GD/ ∞ /∞) (ii) (M/M/1) : (GD/ N /∞) (iii) (M/M/c) : (GD/∞/∞) (iv) (M/M/c) : (GD/ N /∞) (v) (M/M/∞) : (GD/ ∞ /∞)		

T.Y.B.Sc	Theory Semester VI :
RJSUSTA601 Paper-I	Course Outcomes 6.1 : This course will help students

Distribution theory and Stochastic Processes	1. various other stochastic processes such as Poisson process, birth and death processes, queuing process. 2. application of these processes in real life problems. 3. practical aspects relevant to above problems based on the considered topics. Learning outcomes: The students will be able ➢ to strengthen the concepts in bivariate normal distribution. ➢ to prepare students to develop stochastics and queueing models. ➢ practical aspects relevant to above problems based on the considered topics.

SEMESTER VI (THEORY)		**L**	**Cr**
Paper-II: Testing of Hypothesis	**Paper Code: RJSUSTA602**	60	2.5
UNIT I		15	
MOST POWERFUL TESTS			
1	Problem of testing hypothesis.		
2	Definitions and illustrations of i) Simple hypothesis ii) Composite hypothesis iii) Null Hypothesis iv) Alternative Hypothesis v)Test of hypothesis vi) Critical region vii) Type I and Type II errors viii) Level of significance ix) p-value x) size of the test xi) Power of the test xii) Power function of a test xiii) Power curve.		
3	Definition of the most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Randomized test.		

	UNIT II	15	
	UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS		
1	Definition, Existence and Construction of uniformly most powerful (UMP) test.		
2	Likelihood ratio principle. Definition of test statistic and its asymptotic distribution (statement only). Construction of LRT for the mean of normal distribution for i) known σ^2 ii) unknown σ^2 (two sided alternatives). LRT for variance of normal distribution for i) known μ ii) unknown μ (two-sided alternatives hypothesis).		
	UNIT III	15	
	SEQUENTIAL PROBABILITY RATIO TEST (SPRT)		
1	Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure.		
2	Definition of Wald's SPRT of strength (α, β). Graphical / Tabular procedure for carrying out the tests. Problems based on Bernoulli, Binomial, Poisson, Normal and Exponential distributions.		
	UNIT IV		
	NON-PARAMETRIC TESTS	15	
1	Need for non parametric tests.		
2	Distinction between a parametric and a non parametric test.		
3	Concept of a distribution free statistic. Single sample and two sample Nonparametric tests. (i) Sign test (ii) Wilcoxon's signed rank test (iii)Median test (iv) Mann–Whitney test (v) Run test (vi) Fisher exact test (vii) Kruskal -Wallis test (viii) Friedman test.		

4	Assumptions, justification of the test procedure for small & large samples.		

T.Y.B.Sc	Theory Semester VI :
RJSUSTA602 Paper-II Testing of Hypothesis	Course Outcomes 6.2 : This course will provide the students with knowledge of 1. formulating and testing a hypothesis, using critical values to draw conclusions and determining probability of making errors in hypothesis tests. 2. advanced level topics in statistical inference on testing of statistical hypotheses. 3. using Neyman Pearson Lemma and finding Uniformly Most Powerful Test. 4. likelihood ratio test and its applications. 5. Wald's Sequential Probability Ratio Test. 6. understand and analyze various methods of Non-parametric tests. Learning outcomes: This topic will help students ➢ to empower to validate assumptions made on population parameters. ➢ to differentiate between parametric and nonparametric tests.

SEMESTER VI (THEORY)		L	Cr
Paper-III: Operation Research Techniques	**Paper Code: RJSUSTA603**	60	2.5
UNIT I		15	
LINEAR PROGRAMMING PROBLEM			
1	Two-Phase Simplex Method, Algorithm. Dual Simplex Method, Algorithm. Post Optimality Sensitivity Analysis.		
2	Effect on optimal solution to the LPP and improvement in the solution due to (i) Change in cost coefficient, (ii) Change in the element of requirement vector, (iii) Addition/deletion of a variable, (iv) Addition/deletion of a constraint (All expression without proof).		
UNIT II		15	
INVENTORY CONTROL			
1	Introduction to Inventory Problem . Deterministic Models : Single item static EOQ models for (i) Constant rate of demand with instantaneous replenishment, with and without shortages. (ii) Constant rate of demand with uniform rate of replenishment, with and without shortages.		

2	(iii) Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks. Probabilistic models : Single period with (i) Instantaneous demand (discrete and continuous) without setup cost. (ii) Uniform demand (discrete and continuous) without set up cost.		
	UNIT III	15	
	REPLACEMENT THEORY		
1	Replacement of items that deteriorate with time and value of money i) remains constant ii) changes with time. Replacement of items that fail completely: Individual replacement and Group replacement policies.		
	UNIT IV		
	SIMULATION AND RELIABILITY	15	
1	Concept and Scope of simulation. Monte Carlo Technique of Simulation.Generation of random numbers using (i) Mid. Square Method and (ii) Multiplicative Congruential Method. Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. Simulation techniques applied to inventory and queueing models. Reliability: Concept of reliability, Hazard-rate. Bath-tub curve. Failure time distributions : (i) Exponential, (ii) Gamma,(iii) Weibull, (iv) Gumbel. Definitions of increasing (decreasing) failure rate. System Reliability. Reliability of (i) series ; (ii) parallel system of		

	independent components having exponential life distributions. Mean Time to Failure of a system (MTTF).		

T.Y.B.Sc	Theory Semester VI :
RJSUSTA603 Paper-III Operation Research Techniques	Course Outcomes 6.3: This course will provide the students with a knowledge of 1. simplex method of solving linear programming problem (LPP) for finding degenerate, unbounded, alternate and infeasible solutions. 2. duality to solve a LPP. 3. inventory management's principles, concepts, and techniques as they relate to the entire supply chain (customer demand, distribution, and product transformation processes). 4. Identifying the reliability testing components. Learning outcomes: This course will help students ➢ to orient students on various applications of statistics in industry. ➢ to optimize the business outcome.

	➢ to understand how reliability works in real life situations.

SEMESTER VI (THEORY)		L	Cr
Paper-IV: Elements of Actuarial Science	**Paper Code: RJSUSTA604**	60	2.5
UNIT I		15	
MORTALITY TABLES			
1	Definitions of (i) Crude Death Rate (ii)Specific Death Rates (iii) Standardised Death Rates (iv)Crude Birth Rate (v)General Fertility Rate (vi)Specific Fertility Rate (vii) Total Fertility Rate (viii) Pearl's Vital Index (ix)Gross Reproduction rate (x)Net Reproduction rate. Various mortality functions. Probabilities of living and dying. The force of mortality. Estimation of μ_x from the mortality table.Laws of mortality: Gompertz's and Makeham's first law. Select, Ultimate andAggregate mortality tables. Stationary population. Central Mortality Rate Expectation of life and Average life at death.		

	UNIT II	15	
	COMPOUND INTEREST AND ANNUITIES CERTAIN		
1	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 (i) increasing annuity (ii) increasing annuity when successive installments form arithmetic progression (iii) annuity with frequency different from that with which interest is convertible. Redemption of loan.		
	UNIT III	15	
	LIFE ANNUITIES		
1	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).		
	UNIT IV		
	ASSURANCE BENEFITS	15	
1	Present value of Assurance benefits in terms of commutation functions of : (i) pure endowment assurance (ii) temporary assurance (iii) endowment assurance (iv) whole life assurance (v) double endowment assurance (vi) special endowment assurance (vii) deferred temporary assurance Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Natural and Office		

	premiums.		

T.Y.B.Sc	Theory Semester VI :
RJSUSTA604 Paper IV Elements of Actuarial Science	Course Outcomes 6.4 : This course will provide the students with knowledge of 1. different concepts of Mortality, fertility rate, death rate, various mortality tables and life tables. 2. compound interest, Present value & Accumulated value & different types of annuities. 3. Assurance & Premium. Learning outcomes: This course help students to understand ➢ how to solve real life problems of mortality, fertility rate, life tables. ➢ how the problem of Compound Interest, Present Value, Accumulated Value & different types of annuities can be solved. ➢ problem solving of Assurance benefits & Premium.

Semester V (PRACTICALS)		L	Cr
Practical-I: Probability and Distribution Theory	**Paper Code: RJSUSTA501**		1.5
1	Probability-1		
2	Probability -2		
3	Probability -3		
4	Multinomial Distribution		
5	Order Statistics -1		
6	Order Statistics -2		
Practical-II: Theory of Estimation	**Paper Code: RJSUSTA502**		1.5
1	MVUE and MVBUE		
2	Method of Estimation -1		
3	Method of Estimation -2		
4	Bayes' Estimation		
5	Confidence Interval		
6	Linear model		

Practical-III: Biostatistics		**Paper Code: RJSUSTA503**		1.5
1	Epidemic models			
2	Direct Assays			
3	Quantal Response Assays			
4	Parallel line Assay			
5	Clinical Trials			
6	Bioequivalence			
Practical-IV: Regression Analysis using R software		**Paper Code: RJSUSTA504**		1.5
1	Fundamentals of R			
2	Graphs using R			
3	Diagrams using R			
4	Simple Linear Regression using R			
5	Multiple Linear Regression using R			
6	Weighted Least Square using R			

T.Y.B.Sc	Practical Semester V
RJSUSTAP501 Practicals of Course RJSUSTA501 + Course RJSUSTA502	Course Outcomes: Upon successful completion of this course, students will be able to: 1. Use the basic probability rules, including additive and multiplicative laws, using the terms, independent and mutually exclusive events. 2. Translate real-world problems into probability models. 3. Identify the type of statistical situation to which different distributions can be applied. 4. Draw conclusions about the whole population on the basis of a sample. Learning outcomes: The students will get acquainted with some important and useful concepts on ➢ on various topics such as probability, multinomial distribution, estimation techniques and linear models so that they can apply the relevant concepts to real life problems.

T.Y.B.Sc	Practical Semester V
RJSUSTAP502 Practicals of Course RJSUSTA503 + Course RJSUSTA504	Course Outcomes: This course will provide the students with knowledge of 1. Simple and multiple linear regression models and their applications. Learning Outcomes: This course help students to understand ➢ application of various topics such as clinical trials, Bioassay, Epidemics and Bioequivalence.

	➢ application of various topics such as simple linear regression, multiple linear regression and assumptions of linear regression so that they can apply the relevant concepts to real life problems.

Semester VI (PRACTICALS)		L	Cr
Practical-I: Distribution theory and Stochastic Processes	**Paper Code: RJSUSTA601**		1.5
1	Bivariate Normal Distribution		
2	Tests for correlation and Interval estimation		
3	Generating Function		
4	Stochastic Process		
5	Queuing Theory -1		
6	Queuing Theory -2		
Practical-II: Testing of Hypothesis	**Paper Code: RJSUSTA602**		1.5
1	Testing of Hypothesis- 1		
2	Testing of Hypothesis-2		
3	SPRT		
4	Non Parametric test-1		
5	Non Parametric test-2		
Practical-III: Operation Research Techniques	**Paper Code: RJSUSTA603**		1.5

1	L.P.P.		
2	Inventory Control - I		
3	Inventory Control - II		
4	Replacement Theory		
5	Simulation		
6	Reliability		
Practical-IV: Elements of Actuarial Sciences	**Paper Code: RJSUSTA604**		1.5
1	Mortality table		
2	Mortality table II		
3	Annuities I		
4	Annuities II		
5	Life Annuities		
6	Assurance benefits		

T.Y.B.Sc	Semester VI

RJSUSTAP601 Practicals of Course RJSUSTA601 + Course RJSUSTA602	Course Outcomes: Upon successful completion of this course, students will be able to: 1. calculate probabilities, and derive the marginal and conditional distributions of bivariate random variables. 2. the fundamental concepts of stochastic processes. 3. Poisson process and its variations. 4. knowledge about important inferential aspects such as point estimation, test of hypotheses and associated concepts. Learning outcomes: This course help students to understand ➢ various topics such as bivariate normal distribution, queuing theory and Inferential statistics so that they can apply the relevant concepts to real life problems.

T.Y.B.Sc	Practical Semester VI
RJSUSTAP602 Practicals of Course RJSUSTA603 + Course RJSUSTA604	Course Outcomes: Upon successful completion of this course, students will be able to 1. solve problems of Mortality , death rate, expectation of life. 2. solve problems of Annuities, Compound Interest, etc 3. solve problems of Life Annuities, Assurance & Premiums. 4. solve problems of Inventory and simulation. Learning outcomes: This course help students to understand ➢ This course shall provide knowledge of practical application of various topics such as Inventory control, Replacement Theory, Simulation and LPP.

	➢ identification, analysis & interpretation of real-life problems of Mortality, Annuity, Assurance & Premiums.

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Scheme of Examinations

1. Two Internals of 20 marks each. Duration 30 min for each.
2. One External (Semester End Examination) of 60 marks. Duration: 2 hours.
3. One Practical at the end of Semester consisting of Practical I 50 marks, Practical II 50 marks, Practical III 50 marks and Practical IV 50 marks. But combined passing for paper I and Paper II out of 100 and combined passing for paper III and paper IV out of 100.
4. Minimum marks for passing Semester End Theory and Practical Exam is 40 %.
5. Students must appear at least one of the two Internal Tests to be eligible for the Semester End Examination.
6. For any KT examinations, there shall be ODD-ODD/EVEN-EVEN pattern followed.
7. A candidate will be allowed to appear for the practical examinations if he/she submits a certified journal of T.Y.B.Sc. Statistics or a certificate from the Head of the department / Institute to the effect that the candidate has completed the practical course of T.Y.B.Sc. Statistics as per the minimum requirements.
8. In case of loss of journal, a candidate must produce a certificate from the Head of the department /Institute that the practical's for the academic year were completed by the student. However, such a candidate will be allowed to appear for the practical examination but the marks allotted for the journal will not be granted.
9. HOD's decision, in consultation with the Principal, shall remain final and abiding to all.

Evaluation and Assessment

Evaluation (Theory): Total marks per course - 100.

CIA- 40 marks

CIA 1: Written test -20 marks

CIA 2: Written Test / Assignment -20 marks

Semester End Examination – 60 marks

Question paper covering all units

Course Semester End Examination in Semester V and VI

(RJSUSTA501, RJSUSTA502, RJSUSTA503, RJSUSTA504, RJSUSTA601, RJSUSTA602, RJSUSTA603 & RJSUSTA604)

Pattern of Theory question paper at the end of the semester for each course : There shall be Four compulsory Questions of Fifteen marks each with an internal option. Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III, Question 4 based on Unit IV.

Question	Knowledge	Understanding	Application and analyses	Total marks- Per unit
Unit 1	08	04	03	15
Unit 2	08	04	03	15
Unit 3	08	04	03	15
Unit 4	08	04	03	15
-TOTAL- Per objective	32	16	12	**60**
% WEIGHTAGE	53.33	26.67	20	**100%**

Evaluation of Practicals 200 marks/Semester

Evaluation of Practicals 200 marks (100 marks for each practical RJSUSTAP501 (Based on RJSUSTA501 and RJSUSTA502), & RJSUSTAP502 (Based on RJSUSTA503 and RJSUSTA504), AND RJSUSTAP601 (Based on RJSUSTA601 and RJSUSTA602), & RJSUSTAP602 (Based on RJSUSTA603 and RJSUSTA604).

In each paper students will attempt 1 question out of 2 questions, each of 40 marks. Each question will have at least four sub-questions. Journal-05 marks, Viva-05 marks.

SEMESTER V: 100 marks for each practical RJSUSTAP501(Based on RJSUSTA501 and RJSUSTA502), RJSUSTAP502(based on RJSUSTA503 and RJSUSTA504)

SEMESTER VI: 100 marks for each practical RJSUSTAP601(Based on RJSUSTA601 and RJSUSTA602), RJSUSTAP502(based on RJSUSTA603 and RJSUSTA604)

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

Mapping of the course to employability/ Entrepreneurship/skill development

Class	Course Name	Course Code	Topic focusing on Employability/ Entrepreneurship/skill development	Employability/ Entrepreneurship/ Skill development	Specific activity
TYBSC SEM V	Probability and Distribution Theory	RJSUSTA501	Unit 1. Probability-I Unit 2. Probability-II	1. Employability in the field of sports, weather reports etc.	
	Theory of Estimation	RJSUSTA502	Unit 1. Point estimation and Properties of estimator -1 Unit 2. Methods of point estimation Unit 4. Introduction to Linear models	1. Model building skills	
	Biostatistics	RJSUSTA503	Unit 3. Clinical Trials Unit 4. Bioequivalence	1. Employability in the field of Clinical Research	

	Regression Analysis Using R software	RJSUSTA504	Unit 1- Fundamental of R Unit 2 - Simple Linear Regression Model Unit 3 - Multiple Linear Regression Model Unit 4- Validity of Assumptions	1. Computer Programming skills 2. Employability in the field of Machine learning and data science	
TYBSC SEM VI	Distribution theory and Stochastic Processes	RJSUSTA601	Unit 3. Stochastic processes Unit 4. Queuing theory	1. Critical thinking 2. Problem solving abilities	
	Testing of Hypothesis	RJSUSTA602	Unit 1. MP Test Unit 2. UMP Test and LRT Unit 3. SPRT Unit 4. Non Parametric Tests	1. Analytical Skills 2. Critical thinking	
	Operations Research Techniques	RJSUSTA603	Unit 1- LPP Unit 2- Inventory Control Unit 3- Replacement Theory Unit 4- Simulation and Reliability	1. Critical thinking 2. Problem solving abilities 3. Decision making skills	
	Elements of Actuarial Science	RJSUSTA604	Unit 1. Mortality tables Unit 2. Compound interest and Annuities Certain Unit 3. Life Annuities Unit 4. Assurance Benefits	1. Employability in Insurance sector and Banking sector	