

Deccan Education Society's

**Kirti M. Doongursee College of
Arts, Science and Commerce
(AUTONOMOUS)**



Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Bachelor of Science
Course: T.Y.B.SC.
Subject: STATISTICS

Choice Based Credit System (CBCS)
with effect from
Academic Year 2024-2025

PROGRAM OUTCOMES

PO	Description
A student completing Bachelor's Degree in Science Program will be able to	
PO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate Programme. Execute strong theoretical and practical understanding generated from the specific graduate Programme in the area of work.
PO2	Critical Thinking and Problem solving: Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	Social competence: Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	Research-related skills and Scientific temper: Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	Trans-disciplinary knowledge: Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	Personal and professional competence: Performing dependently and collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

**Deccan Education Society's
Kirti M. Doongursee College (Autonomous)**

Proposed Curriculum as per Autonomy

Year of implementation- 2024-25

Name of the Department: Statistics

Semester	Course Code	Course Title	Credit
V	KUSSTAT24501	Probability and Distribution Theory	2.5
	KUSSTAT24502	Theory of Estimation	2.5
	KUSSTAT24503	Biostatistics	2.5
	KUSSTAT24504	Regression Analysis using R Software	2.5
	KUSSTAT24P5	Practicals of course KUSSTAT24501 + KUSSTAT24502	3
	KUSSTAT24P6	Practicals of course KUSSTAT24503 + KUSSTAT24504	3
VI	KUSSTAT24601	Distribution Theory and Stochastic Processes	2.5
	KUSSTAT24602	Testing of Hypothesis	2.5
	KUSSTAT24603	Operations Research Techniques	2.5
	KUSSTAT24604	Actuarial Science	2.5
	KUSSTAT24P7	Practicals of course KUSSTAT24601 + KUSSTAT24602	3
	KUSSTAT24P8	Practicals of course KUSSTAT24603 + KUSSTAT24604	3

NB: The syllabus is likely to change, subject to the revision that might be recommended by University of Mumbai.

Course Code	SEM – V – Paper I	Credits	Lectures/Week
KUSSTAT24501	Probability and Distribution Theory	2.5	4
<p>Course Outcomes: After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Explain mathematical, statistical, axiomatic, and subjective probability, and apply them in various scenarios. • Understand and apply Bayes' theorem to calculate conditional probabilities in real-world problems. • Calculate probabilities of at least one, exactly m, and at least m out of N events. • Apply Trinomial distribution & Multinomial distribution in practical situations. • Derive properties of order statistics, including distributions of maximum and minimum observations. 			
Unit	Topics	No of Lectures	
I	<p>Probability</p> <ol style="list-style-type: none"> 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. Addition Theorem for (a) two (b) three events. (iv) Conditional Probability: Multiplication Theorem for two, three events. 4. Bayes' theorem. (vi) Theorems on Probability of realization of: <ul style="list-style-type: none"> (a) At least one (b) Exactly m (c) At least m of N events $A_1, A_2, A_3 \dots A_N$. <p>Classical occupancy problems, Matching and Guessing problems. Problems based on them.</p>	15	
II	<p>Inequalities and Law of Large Numbers</p> <ol style="list-style-type: none"> 1. Markov Inequality 2. Tchebyshev's Inequality 	15	

	<ol style="list-style-type: none"> 3. Boole's Inequality 4. Cauchy Schwartz's Inequality 5. Weak law of large numbers. 	
III	<p>Joint Moment Generating Function, Trinomial Distribution and Multinomial Distribution</p> <ol style="list-style-type: none"> 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 Bivariate 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). 3. Distribution of the Sum X+Y Extension to Multinomial distribution with parameters (n, p_1, p_2, \dots, p_{k-1}) where $p_1 + p_2 + \dots + p_{k-1} + p_k = 1$. Expression for joint MGF. Derivation of: joint probability distribution of (X_i, X_j). Conditional probability distribution of X_i. 	15
IV	<p>Order Statistics</p> <ol style="list-style-type: none"> 1. Definition of Order Statistics based on a random sample. 2. Derivation of: <ol style="list-style-type: none"> a) Cumulative distribution function of r^{th} order statistic. b) Probability density functions of the r^{th} order statistic. 	15

	<p>c) Joint Probability density function of the r^{th} and the s^{th} order statistic ($r < s$).</p> <p>d) Joint Probability density functions of all n ordered statistics.</p> <p>e) Distribution of Maximum observation (nth order statistic) and Minimum observation (first order statistic) in case of uniform and Exponential distribution.</p> <p>f) Probability density function of the difference between r^{th} and s^{th} order statistic ($r < s$) in case of uniform and Exponential distribution.</p>	
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Textbooks:

- Feller W: An introduction to probability theory and its applications, Volume: 1, Third edition, Wiley Eastern Limited.
- Hogg R V. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
- Mood A. M., Graybill F. A., Boes D. C.: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
- Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
- Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
- Biswas S.: Topics in Statistical Methodology, First edition, Wiley Eastern Ltd.
- Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
- Chandra T.K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
- S.C. Gupta and V. K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand and Sons V K Rohatgi: An Introduction to probability and Mathematical Statistics.

Course Code	SEM – V – Paper II	Credits	Lectures/Week
KUSSTAT24502	Theory of Estimation	2.5	4

Course Outcomes:

After successful completion of this course, students would be able to:

- Differentiate between statistic, estimator, and estimate.
- Analyze properties of good estimators such as unbiasedness, consistency, and sufficiency, efficiency.
- Apply Maximum Likelihood Estimation (MLE) and Method of Moments to derive estimators for standard distributions.
- Calculate confidence intervals for population mean and variance
- Understand concept of linear models and their applications in estimation.

Unit	Topics	No of Lectures
I	<p>Point Estimation & Properties of Estimators</p> <ol style="list-style-type: none"> 1. Notion of a Parameter and Parameter Space. 2. Problem of Point estimation. 3. Definitions: Statistic, Estimator and Estimate. 4. Properties of a good estimator: <ol style="list-style-type: none"> a) Unbiasedness: Definition of an unbiased estimator, Illustrations and examples. Proofs of the following results: <ol style="list-style-type: none"> (i) Two distinct unbiased estimators of $U(\theta)$ give rise to infinitely many unbiased estimators. (ii) If T is an unbiased estimator of $U(\theta)$ then $U(T)$ is an unbiased estimator of $U(\theta)$ provided $U(\)$ is a linear function. b) Consistency: Definition of Consistency. Sufficient condition for consistency, proof & Illustrations. c) Sufficiency: Concept and Definition of sufficient statistic. Neyman's Factorization theorem (without proof). Exponential family of probability distributions and sufficient statistics. 	15

	<p>d) Relative efficiency of an estimator & illustrative examples.</p> <ol style="list-style-type: none"> 1. Minimum variance unbiased estimator (MVUE) and Cramer Rao Inequality: Definition of MVUE. 2. Uniqueness property of MVUE (proof). 3. Fisher's information function 4. Regularity conditions. 5. Statement and proof of Cramer-Rao inequality. 6. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. 7. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE. 	
II	<p>Methods of Point Estimation</p> <p>Method of Maximum Likelihood Estimation (M.L.E.):</p> <ol style="list-style-type: none"> 1. Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. 2. Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). 3. Properties of MLE (without proof). <p>Method of Moments:</p> <ol style="list-style-type: none"> 1. Derivation of Moment estimators for standard distributions (case of one and two unknown parameters). 2. Illustrations of situations where MLE and Moment Estimators are distinct and their comparison using Mean Square error. <p>Method of Minimum Chi-square and Modified Minimum Chi-Square.</p>	15

<p style="text-align: center;">III</p>	<p>Bayesian Estimation Method and Interval Estimation</p> <p>Bayes Estimation:</p> <ol style="list-style-type: none"> 1. Prior distribution, Posterior distribution 2. Loss function, Risk function 3. Types of Loss function: Squared error Loss function. (SELF), Absolute error Loss function (AELF) 4. Bayes' risk. 5. Bayes' method of finding Point estimator (assuming SELF). <p>Examples:(i) Binomial- Beta (ii) Poisson- Gamma (iii) Gamma-Gamma (iv) Normal-Normal.</p> <p>Interval Estimation:</p> <ol style="list-style-type: none"> 1. Concept of confidence interval & confidence limits. 2. Definition of Pivotal quantity and its use in obtaining confidence limits. 3. Derivation of 100(1-α) % equal tailed confidence interval for: <ol style="list-style-type: none"> a) The population mean: μ, $\mu_1 - \mu_2$ (population variance (known/ unknown). b) the population variance: $\sigma^2, \frac{\sigma_1^2}{\sigma_2^2}$ (Normal distribution). Confidence interval for the parameters of Binomial, Poisson and Exponential distributions. 	<p style="text-align: center;">15</p>
<p style="text-align: center;">IV</p>	<p>Introduction to Linear Models</p> <ul style="list-style-type: none"> • Explanation of General Linear Model of full rank with assumptions. Model: $Y = X\beta + \underline{e}$ where $\underline{e} \sim N(0, \sigma^2 I)$ • Derivation of : 1) Least squares estimator of $\underline{\beta}$ 2) $E(\hat{\underline{\beta}})$ 3) $V(\hat{\underline{\beta}})$ 	<p style="text-align: center;">15</p>

	<ul style="list-style-type: none"> • GuassMarkoff theorem for full rank Model: $Y = X\beta + e$. • Derivation of : 1) $E(I' \hat{\beta})$ 2) $V(I' \hat{\beta})$. • Confidence interval for $I'\beta$ when σ^2 is known. • Confidence interval of $\hat{\beta}$ when σ^2 is known. 	
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Textbooks:

- Hogg R.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
- Hogg R.V., Tannis E. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
- Rohatgi, V. K, Ehsanes Saleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics, Second Edition, Wiley series in Probability and Statistics.
- John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
- Hoel P.G.: Introduction to Mathematical Statistics; Fourth Edition; John Wiley & Sons Inc.
- Gupta S.C., Kapoor V.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
- Kapur J. N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
- Arora Sanjay and Bansilal A.: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi, 5(1989.)
- A. M. Kshirsagar; Linear Models.
- F.A. Graybill; An Introduction to Linear Model.

Course Code	SEM – V – Paper III	Credits	Lectures/Week
KUSSTAT24503	Biostatistics	2.5	4
Course Outcomes:			
After successful completion of this course, students would be able to:			
<ul style="list-style-type: none"> • Understand the features of epidemic spread and define various terms involved in epidemics. • Analyze simple mathematical models for epidemics, including deterministic models without removals and the Carrier model. • Explain the Reed-Frost and Greenwood models and their application to epidemics. • Perform linearizing transformations and analyze parallel line assays, including symmetrical (2,2) and (3,3) parallel line assays. • Describe the need and ethics of clinical trials. • Apply survival analysis to estimate median survival time, using the Kaplan-Meier approach. • Analyze parallel designs using logarithmic transformation and establish bioequivalence using confidence interval approaches (80/125 rule). 			
Unit	Topics	No of Lectures	
I	Epidemic Models <ol style="list-style-type: none"> 1. The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for ‘a’ introductions), 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. 	15	
II	Bioassays <ol style="list-style-type: none"> 1. Meaning and scope of bioassays. Relative potency. Direct assays. Fieller’s theorem. 2. Indirect assays. Dose-response relationship. Conditions of similarity and Monotony. Linearizing transformations. Parallel line 	15	

	<p>assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency.</p> <p>3. Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis.</p>	
III	<p>Clinical Trials</p> <p>1. Introduction to clinical trials: The need and ethics of clinical trials. Common terminology used in clinical trials. Over view 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).</p> <p>2. Types of Trials: Inferiority, Superiority and Equivalence, Multicentric 15 Lectures 12 Trial. Inclusion/Exclusion Criteria. Sample size estimation.</p>	15
IV	<p>Clinical Trials and Bioequivalence</p> <p>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.</p> <p>2. BIOEQUIVALENCE: Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (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).</p> <p>3. Advantages of Crossover design over Parallel design. Analysis of Parallel design using logarithmic transformation (Summary statistics,</p>	15

	ANOVA and 90% confidence interval). Confidence Interval approach to establish bioequivalence (80/125 rule).	
<p>Textbooks:</p> <ul style="list-style-type: none"> ● Bailey N.T.J.: The Mathematical theory of infectious diseases, Second edition, Charles Griffin and Co. London. ● Das M.N. and Giri N. C.: Design and Analysis of Experiments, Second edition, Wiley Eastern. ● Finney D. J.: Statistical Methods in Biological Assays, First edition, Charles Griffin and Co. London. ● Sanford Boltan and Charles Bon: Pharmaceutical Statistics, Fourth edition, Marcel Dekker Inc. ● Zar Jerrold H.: Biostatistical Analysis, Fourth edition, Pearson's education. ● Daniel Wayne W.: Biostatistics. A Foundation for Analysis in the Health Sciences, 7 th Edition, Wiley Series in Probability and Statistics. ● Friedman L. M., Furburg C., Demets D. L.: Fundamentals of Clinical Trials, First edition, Springer Verlag. ● Fleiss J. L. The Design and Analysis of Clinical Experiments, Second edition, Wiley and Sons. ● Shein-Chung-Chow; Design and Analysis of Bioavailability & Bioequivalence studies, Third Edition, Chapman & Hall/CRC Biostatistics series. 		

Course Code	SEM – V – Paper IV	Credits	Lectures/Week
KUSSTAT24504	Regression Analysis using R Software	2.5	4
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Understand the features of R and install the R software. • Process data by importing and exporting, setting working directory, checking data structure, changing variable types, and using the ggplot package for data visualization. • Understand the assumptions of the simple linear regression model and derive ordinary least square (OLS) estimators of regression coefficients. • Perform tests for overall significance of the model, significance of individual coefficients, and confidence intervals for regression coefficients. • Detect autocorrelation using Durbin Watson Test and interpret the test output in R. 			
Unit	Topics	No of Lectures	
I	<p>Fundamentals of R</p> <ol style="list-style-type: none"> 1. Introduction to R features of R, installation of R, Starting and ending R session, getting help in R, Value assigning to variables. 2. Basic Operations: +, -, *, ÷, ^, sqrt. 3. Numerical functions: log 10, log , sort, max, unique, range, length, var, prod, sum, summary, dim, sort, five num etc. 4. Data Types: Vector, list, matrices, array and data frame. 5. Variable Type: logical, numeric, integer, complex, character and factor. 6. Data Manipulation: Selecting random N rows, removing duplicate row(s), dropping a variable(s), Renaming variable(s), sub setting data, creating a new variable(s), selecting of random fraction of row(s), appending of row(s) and column(s), simulation of variables. 7. Data Processing: Data import and export, setting working directory, checking structure of Data: Str(), Class(), Changing type of variable (for eg as.factor, 	15	

	<p>as.numeric).</p> <p>8. 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.</p>	
II	<p>Simple Linear Regression Model</p> <ol style="list-style-type: none"> 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. 2. Procedure of testing: <ol style="list-style-type: none"> a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients. 3. 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. Weighted Least Square Method, Polynomial Regression Models. 	15
III	<p>Multiple Linear Regression Model</p> <ol style="list-style-type: none"> 1. Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2. 2. Procedure of testing: <ol style="list-style-type: none"> a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients. 3. 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. 	15

IV	<p>Validity of Assumptions</p> <ol style="list-style-type: none"> 1. Residual Diagnostics: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots of 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. 3. Heteroscedasticity: Concept and detection using Breusch –Pagan-Godfrey Test, Interpretation of output produced by bptest function in R. 4. Multicollinearity: <ol style="list-style-type: none"> a) Concept and detection using R^2 and t-ratios b) pairwise correlation between regressors iii) Variance Inflation Factor (VIF) c) Interpretation of output produced by mctest function in R. 5. Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures. 6. Ridge Regression: Concept and case study using R, 	15
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Textbooks:

- Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
- Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
- Neter, J., W., Kutner, M. H. Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
- Damodar Gujrati, Sangetha, Basic Econometrics, fourth edition, McGraw Hill Companies.
- William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.
- Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London.
- Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition. Narosa Publishing House, New Delhi.
- Shahababa , B. (2011). Biostatistics with R, Springer, New York.

Course Code	SEM V	Credits	Lectures/Week
KUSTAT24P5	Practical I (Paper I + Paper II)	3	
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Apply basic probability concepts to solve problems. • Use probability theorems to analyze situations involving multiple events. • Understand and apply the Weak Law of Large Numbers. • Calculate probabilities and expected values in trinomial and multinomial distributions. • Apply different methods of estimation, such as Maximum Likelihood Estimation and Method of Moments. • Calculate confidence intervals for population parameters. 			
Paper I			
5.1.1	Probability - I		
5.1.2	Probability - II		
5.1.3	Inequalities and WLLN		
5.1.4	Trinomial and Multinomial Distribution		
5.1.5	Order Statistics - I		
5.1.6	Order Statistics - II		
Paper II			
5.2.1	MVUE and MVBUE		
5.2.2	Methods of Estimation		
5.2.3	Baye's Estimation		
5.2.4	Confidence Interval		
5.2.5	Linear Model		
5.2.6	Use of R Software		

Course Code	SEM V	Credits	Lectures/Week
KUSTAT24P6	Practical II (Paper III + Paper IV)	3	
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Comprehend the principles and procedures of epidemic models, direct assays, parallel line assays, quantal response assays, clinical trials, and bioequivalence. • Assess the significance of results from epidemic models, clinical trials, and bioequivalence etc. in practical scenarios. • Apply R programming skills to create graphs and diagrams for data visualization. • Understand the concepts of simple linear regression, weighted least squares, multiple linear regression, and ridge regression. • Develop and implement linear regression models using R for predictive analysis. 			
Paper III			
5.3.1	Epidemic Models		
5.3.2	Direct Assays		
5.3.3	Parallel Line Assays		
5.3.4	Quantal Response Assays		
5.3.5	Clinical Trials		
5.3.6	Bioequivalence		
Paper IV			
5.4.1	Fundamentals of R		
5.4.2	Graphs using R		
5.4.3	Diagrams using R		
5.4.4	Simple Linear Regression using R		
5.4.5	Weighted Least Square using R		
5.4.6	Multiple Linear Regression and Ridge Regression using R		

Course Code	SEM – VI – Paper I	Credits	Lectures/Week
KUSSTAT24601	Distribution Theory and Stochastic Processes	2.5	4
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Understand the bivariate normal distribution. • Perform tests and construct confidence intervals for correlation coefficients in different scenarios. • Define generating functions and probability generating functions and express mean and variance in terms of generating functions. • Understand the convolution of sequences and compute generating functions of standard discrete distributions. • Define stochastic processes and understand the postulates and differential equations for various processes like pure birth, Poisson, Yule Furry, pure death, and birth-death processes. • Explain the basic elements of queuing models and the roles of Poisson and Exponential distributions. • Calculate various average characteristics for different queuing models. 			
Unit	Topics	No of Lectures	
I	<p>Bivariate Normal Distribution</p> <ol style="list-style-type: none"> 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 condition for the independence of X and Y. Distribution of $aX + bY$, where 'a' and 'b' are constants. 3. Distribution of sample correlation coefficient when $\rho = 0$. Testing the significance of a correlation coefficient. Fisher's z – transformation. 4. Tests for a) $H_0: \rho = \rho_0$ b) $H_0: \rho_1 = \rho_2$, Confidence interval for ρ. 	15	

<p style="text-align: center;">II</p>	<p>Generating Functions</p> <ol style="list-style-type: none"> 1. Definitions of generating function and probability generating function. Expression for mean and variance in terms of generating functions. 2. Definition of a convolution of two or more sequences. Generating function of a convolution. Generating functions of the standard discrete distributions. 3. Relation between: a) Bernoulli and Binomial distributions b) Geometric and Negative Binomial distributions in terms of convolutions. 	<p style="text-align: center;">15</p>
<p style="text-align: center;">III</p>	<p>Stochastic Processes</p> <ol style="list-style-type: none"> 1. Definition of stochastic process. 2. Postulates and difference differential equations for: <ol style="list-style-type: none"> a) Pure birth process b) Poisson process with initially 'a' members, for $a = 0$ and $a > 0$ c) Yule Furry process d) Pure death process e) Death process with $\mu_n = \mu$ f) Death process with $\mu_n = n\mu$ g) Birth and death process h) Linear growth model. <p>Derivation of $P_n(t)$, mean and variance where ever applicable.</p>	<p style="text-align: center;">15</p>
<p style="text-align: center;">IV</p>	<p>Queuing Theory</p> <ol style="list-style-type: none"> 1. Basic elements of the Queuing model. 2. Roles of the Poisson and Exponential distributions. 3. Derivation of Steady state probabilities for birth and death process. 4. Steady state probabilities and various average characteristics for the following models: <ol style="list-style-type: none"> a) (M/M/1) : (GD/ ∞ /∞) b) (M/M/1) : (GD/ N /∞) c) (M/M/c) : (GD/∞/∞) d) (M/M/c) : (GD/ N /∞) e) (M/M/∞) : (GD/ ∞ /∞). 	<p style="text-align: center;">15</p>

Textbooks:

- Feller W: An introduction to probability theory and its applications, Volume: 1, Third edition, Wiley Eastern Limited.
- Hogg R. V. & Craig A.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.
- Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
- Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
- Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
- Taha H.A.: Operations Research: An introduction, Eighth edition, Prentice Hall of India Pvt. Ltd.
- Medhi J: Stochastic Processes, Second edition, Wiley Eastern Ltd.
- Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
- Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.

Course Code	SEM – VI – Paper II	Credits	Lectures/Week
KUSSTAT24602	Testing of Hypothesis	2.5	4

Course Outcomes:

After successful completion of this course, students would be able to:

- Define the problem of testing hypotheses.
- Understand the definitions, existence, and construction of uniformly most powerful (UMP) tests.
- Apply the concepts of most powerful tests, UMP tests, and LRTs to solve problems related to hypothesis testing.
- Analyze and evaluate the need for non-parametric tests compared to parametric tests.
- Construct SPRT procedures for testing simple null hypotheses against simple alternative hypotheses.

Unit	Topics	No of Lectures
I	<p>Most Powerful Tests</p> <ol style="list-style-type: none"> 1. Problem of testing of hypothesis. 2. Definitions and illustrations of: <ol style="list-style-type: none"> a) Simple hypothesis b) Composite hypothesis c) Null Hypothesis d) Alternative Hypothesis e) Test of hypothesis f) Critical region g) Type I and Type II errors h) Level of significance i) p-value x) Size of the test j) Power of the test k) Power function of a test l) Power curve. 3. Definition of most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Randomised test. 	15
II	<p>Uniformly Most Powerful and Likelihood Ratio Tests</p> <ol style="list-style-type: none"> 1. Definition, Existence and Construction of Uniformly most powerful (UMP) test. 	15

	<ol style="list-style-type: none"> 2. Likelihood ratio principle: Definition of test statistic and its asymptotic distribution (statement only). 3. Construction of LRT for the mean of Normal distribution for: <ol style="list-style-type: none"> a) Known σ^2 b) Unknown σ^2 (two sided alternatives). 4. LRT for variance of normal distribution for: <ol style="list-style-type: none"> a) known μ b) unknown μ (two sided alternatives hypothesis). 	
III	<p>Sequential Probability Ratio Tests</p> <ol style="list-style-type: none"> 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 SPRT. 3. Problems based on Bernoulli, Binomial. Poisson, Normal & Exponential distributions. 	15
IV	<p>Non-parametric Tests</p> <ol style="list-style-type: none"> 1. Need for non-parametric tests. 2. Distinction between a parametric and a non-parametric test. 3. Concept of a distribution free statistic. 4. Single sample and two sample Nonparametric test: (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 5. Assumptions, justification of the test procedure for small & large samples. 	15
<p>Textbooks:</p> <ul style="list-style-type: none"> ● Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics, Fourth edition London Macmillan Co. Ltd. ● Hogg R.V. and Tanis E.A.: Probability and Statistical Inference, Third edition Delhi Pearson Education. 		

- Lehmann, E. L: Testing of Statistical Hypothesis, Wiley & Sons.
- Rao, C. R.: Linear Statistical Inference and its applications, Second Edition Wiley Series in Probability and Statistics.
- Daniel W.W.:Applied Non Parametric Statistics, First edition Boston-Houghton Mifflin Company.
- Wald A.: Sequential Analysis, First edition New York John Wiley & Sons.
- Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics, Tenth edition New Delhi S. Chand & Company Ltd.
- Sanjay Aroraand Bansilal: New Mathematical Statistics, SatyaPrakashan, New Market, New Delhi, 5(1989).
- Sidney Siegal& N John Castellan Jr.:Non parametric test for behavioral sciences, McGraw Hill c-1988.
- A. Mood, F. Graybill& D. Boes:Introduction to the theory of Statistics- McGraw Hil.

Course Code	SEM – VI – Paper III	Credits	Lectures/Week
KUSSTAT24603	Operations Research Techniques	2.5	4
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Understand the concepts and scope of simulation. • Apply the two-phase simplex method, dual simplex method, and sensitivity analysis to solve linear programming problems. • Analyze inventory control and replacement problems to determine the most cost-effective policies. • Assess the reliability of systems using different failure time distributions and system reliability models. 			
Unit	Topics	No of Lectures	
I	<p>Linear Programming Problem</p> <ol style="list-style-type: none"> 1. Two-Phase Simplex Method, Algorithm. 2. Dual Simplex Method, Algorithm. 3. Post Optimality Sensitivity Analysis. 4. Effect on optimal solution to the LPP and improvement in the solution due to: <ol style="list-style-type: none"> a) Change in cost coefficient b) Change in the element of requirement vector c) Addition/deletion of a variable d) Addition/deletion of a constraint. <p>(All expressions without proof).</p>	15	
II	<p>Inventory Control</p> <p>Introduction to Inventory Problem</p> <p>Deterministic Models:</p> <p>Single item static EOQ models for:</p> <ol style="list-style-type: none"> a) Constant rate of demand with instantaneous replenishment, with and without shortages. b) Constant rate of demand with uniform rate of replenishment, with and without shortages. c) Constant rate of demand with instantaneous replenishment without shortages, with at most 	15	

	<p>two price breaks.</p> <p>Probabilistic models:</p> <p>Single period with:</p> <ul style="list-style-type: none"> a) Instantaneous demand (discrete and continuous) without setup cost. b) Uniform demand (discrete and continuous) without set up cost. 	
III	<p>Replacement</p> <ul style="list-style-type: none"> 1. Replacement of items that deteriorate with time and value of money: <ul style="list-style-type: none"> a) remains constant b) changes with time. 2. Replacement of items that fail completely: Individual replacement and Group replacement policies. 	15
IV	<p>Simulation and Reliability</p> <ul style="list-style-type: none"> 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. 2. Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. 3. Simulation techniques applied to inventory and queueing model. 4. RELIABILITY: Concept of reliability, Hazard-rate. Bath tub curve. Failure time distributions: (i) Exponential, (ii) Gamma, (iii) Weibull, (iv) Gumbel, 5. Definitions of increasing (decreasing) failure rate. System Reliability. 6. Reliability of: (i) series (ii) parallel system of independent components having exponential life distributions. Mean Time to Failure of a system (MTTF). 	15

Textbooks:

- Vora N. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
- Kantiswarup, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
- Sharma S. D.: Operations Research, Eighth edition, Kedarnath Ramnath & Co.
- Taha Hamdy A.: Operations Research: Eighth edition, Prentice Hall of India Pvt. Ltd.
- Barlow R. E. and Prochan Frank: Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
- Mann N. R., Schafer R.E., Singapurwalla N. D.: Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.

Course Code	SEM – VI – Paper IV	Credits	Lectures/Week
KUSSTAT24604	Acturial Science	2.5	4

Course Outcomes:

After successful completion of this course, students would be able to:

- Recall the various mortality functions and probabilities of living and dying from mortality tables.
- Understand the concepts of select, ultimate, and aggregate mortality tables.
- Apply the concepts of assurance benefits to calculate present values and net premiums for various assurance plans.
- Understand the concepts of life annuities, temporary life annuities, and assurance benefits, including present value calculations.

Unit	Topics	No of Lectures
I	<p>Mortality Tables</p> <ol style="list-style-type: none"> 1. Various mortality functions. Probabilities of living and dying. 2. The force of mortality. Estimation of μ_x from the mortality table. Central Mortality Rate. 3. Laws of mortality: Gompertz's and Makeham's first law. 4. Select, Ultimate and Aggregate mortality tables. Stationary population. Expectation of life and Average life at death. 	15
II	<p>Compound Interest and Annuities Certain</p> <ol style="list-style-type: none"> 1. Accumulated value and present value, nominal and effective rates of interest. Varying rates of interest. 2. 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. 3. Present and accumulated values of: <ol style="list-style-type: none"> a) increasing annuity 	15

	b) increasing annuity when successive instalments form arithmetic progression c) annuity with frequency different from that with which interest is convertible. 4. Redemption of loan.	
III	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. 2. Present values of Variable, increasing life annuities and increasing Temporary life annuities (immediate and due).	15
IV	Assurance Benefits 1. Present value of Assurance benefits in terms of commutation functions of: a) pure endowment assurance b) temporary assurance c) endowment assurance d) whole life assurance e) double endowment assurance f) special endowment assurance g) deferred temporary assurance. 2. Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Natural and Office premiums.	15
Textbooks: <ul style="list-style-type: none"> ● Neill A.: Life Contingencies, First edition, Heineman educational books London. ● Dixit S.P., Modi C.S., Joshi R.V.: Mathematical Basis of Life Assurance, First edition Insurance Institute of India. ● Gupta S. C. & Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons. 		

Course Code	SEM VI	Credits	Lectures/Week
KUSTAT24P7	Practical I (Paper I + Paper II)	3	
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> Remember the procedures for conducting tests for correlation and interval estimation. Apply the concepts of the bivariate normal distribution to analyze and interpret data in practical examples. Apply queuing theory concepts to analyze and optimize queuing systems. Analyze data using hypothesis testing, SPRT, and non-parametric tests to test hypotheses and draw meaningful conclusions. Evaluate the performance of stochastic processes in modeling real-world phenomena. 			
Paper I			
6.1.1	Bivariate Normal Distribution		
6.1.2	Tests for correlation and Interval estimation		
6.1.3	Generating Function		
6.1.4	Stochastic Process		
6.1.5	Queuing Theory - I		
6.1.6	Queuing Theory – II		
Paper II			
6.2.1	Testing of Hypothesis – I		
6.2.2	Testing of Hypothesis – II		
6.2.3	SPRT		
6.2.4	Non-Parametric Test – I		
6.2.5	Non-Parametric Test – II		
6.2.6	Use of R Software		

Course Code	SEM VI	Credits	Lectures/Week
KUSTAT24P8	Practical II (Paper III + Paper IV)	3	
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to:</p> <ul style="list-style-type: none"> • Apply the simplex method to solve linear programming problems and interpret the results. • Understand the Monte Carlo Technique and its application in simulation through practical examples. • Analyze inventory control and replacement problems to determine the most cost-effective policies in practical scenarios. • Interpret mortality tables and calculate life expectancies and probabilities of living and dying in practical cases. • Calculate present and accumulated values of annuities and life annuities in practical scenarios. 			
Paper III			
6.3.1	L.P.P.		
6.3.2	Inventory – I		
6.3.3	Inventory – II		
6.3.4	Replacement		
6.3.5	Simulation		
Paper IV			
6.4.1	Mortality Table - I		
6.4.2	Mortality Table - I		
6.4.3	Annuities – I		
6.4.4	Annuities – II		
6.4.5	Life Annuities		

Evaluation Scheme for Third Year (UG) under AUTONOMY

I. Internal Evaluation for Theory Courses – 40 Marks

- (i) Continuous Internal Assessment 1 (Assignment-Tutorial) – 20 Marks
- (ii) Continuous Internal Assessment 2 – 20 Marks (Class Test with Fill in the Blanks, True or False & Answer the following)

II. External Evaluation for Theory Courses – 60 Marks

Duration: 2 Hours

Theory question paper pattern:

All questions are compulsory.

Qn.	Based on	Type		Options	Marks
Q.1	Unit I, II & III	Objective	MCQs	<i>Attempt all 6</i>	6
			Answer in one sentence	<i>Attempt all 6</i>	6
Q.2	Unit I	Descriptive		<i>Any 2 out of 3</i>	12
Q.3	Unit II	Descriptive		<i>Any 2 out of 3</i>	12
Q.4	Unit III	Descriptive		<i>Any 2 out of 3</i>	12
Q.5	Unit I, II & III	Descriptive		<i>Any 3 out of 6</i>	12

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be sub-divided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

III. Practical Examination

- Each core subject carries 50 Marks (30 marks External + 20 marks Internal)

Sr. No.	Undergraduate Practical Internal Evaluation:	Marks
1	Field Trip/Questionnaire	15
2	Journal	5

Sr. No.	Undergraduate Practical External Evaluation:	Marks
1	Experiment/s	25
2	Viva	5

- Duration: 2 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is compulsory for appearing at the time of Practical Exam.

Note:

Two short field excursions for habitat studies are compulsory. Field work of not less than eight hours duration is equivalent to one period per week for a batch of 15 students.

- A candidate will be allowed to appear for the practical examinations only if he/she submits a certified journal of T.Y.B.Sc. 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. as per the minimum requirements. In case of loss of journal, a candidate must produce a certificate from the Head of the department/Institute that the practicals 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.