ST. JOSEPH'S UNIVERSITY

BENGALURU-27

School of Physical Sciences

DEPARTMENT OF STATISTICS

Syllabus for Bachelor of Science (Basic)

With Statistics as one of the majors with practical with other subject as another major in 3rd year

Under National Education Policy

For Batch 2021 onwards

Name of the Degree Program: B.Sc.

Discipline Core: Statistics

Total Credits for the Program: 136 (till 6 semesters)

Starting year of implementation: 2021-22

Pre requisites for Course: Candidates applying for this course must have studied Mathematics as one of their subjects at the 10 + 2 level.

Program Outcomes

By the end of the program the students will be able to:

1. Acquire fundamental/systematic or coherent understanding of the academic field of Statistics and its different learning areas and applications.
2. Develop and demonstrate an ability to understand major concepts in various disciplines of Statistics.
3. Demonstrate the ability to use skills in Statistics and different practicing areas for formulating and tackling Statistics related problems and identifying and applying appropriate principles and methodologies to solve a wide range of problems associated with Statistics.
4. Understand procedural knowledge that creates different types of professionals related to subject area of Statistics, including professionals engaged in government/public service and private sectors.
5. Plan and execute Statistical experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate statistical software including programming languages, and report accurately the findings of the experiment/investigations.
6. Have a knowledge regarding use of data analytics tools like Excel and R-programming.
7. Developed ability to critically assess a standard report having graphics, probability statements.
8. Analyze, interpret the data and hence help policy makers to take a proper decision.
9. Recognize the importance of statistical modelling and computing, and the role of approximation and mathematical approaches to analyze the real problems using various statistical tools.
10. Demonstrate relevant generic skills and global competencies such as
    i. Problem-solving skills that are required to solve different types of Statistics

related problems with well-defined solutions, and tackle open-ended problems, that belong to the disciplinary-area boundaries;

ii. Investigative skills, including skills of independent thinking of Statistics-related issues and problems;

iii. Communication skills involving the ability to listen carefully, to read texts and reference material analytically and to present information in a concise manner to different groups/audiences of technical or popular nature;

iv. Analytical skills involving paying attention to details and ability to construct logical Arguments using correct technical language related to Statistics and ability to translate them with popular language when needed;

v. ICT skills;

vi. Personal skills such as the ability to work both independently and in a group.

11. Undertake research projects by using research skills- preparation of questionnaire, conducting national sample survey, research projects using sample survey, sampling techniques.

12. Understand and apply principles of least squares to fit a model to the given data, study the association between the variables, applications of Probability Theory and Probability Distributions.

Assessment

Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	**40**	**60**
Practical	**25**	**25**
Projects	**30**	**70**
Experiential Learning (Internships, etc.)	**30**	**70**

Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/ Hons.) etc. with Statistics as Major with practical and any other subject as minor

Sem.	Discipline Core (DSC) (Credits) (L+T+P)	Discipline Elective (DSE) /Open Elective (OE) (Credits) (L+T+P)	Ability Enhancement Compulsory Courses (AECC), Languages (Credits)(L+T+P)		Skill Enhancement Courses (SEC)		Total Credits
					Skill based (Credits) (L+T+P)	Value based (Credits) (L+T+P)	
I	**Descriptive Statistics** (4+2) Discipline B1(4+2)	OE-1 (3)	L1-1 (3), L2-1 (3)(3+1+0 each)		SEC-1: Digital Fluency (2) (1+0+2)		23
II	**Probability and Distributions** (4+2) Discipline B2(4+2)	OE-2 (3)	L1-2(3), L2-2 (3) (3+1+0 each)	Environmental Studies (2)		Health & Wellness/ Social & Emotional Learning (2) (1+0+2)	25
Exit option with Certificate (48 credits)							
III	**Calculus and Probability Distributions** (4+2) Discipline B3(4+2)	OE-3 (3)	L1-3 (3), L2-3(3) (3+1+0 each)		SEC-2: Artificial Intelligence (2)(1+0+2)		23
IV	**Statistical Inference-I** (4+2) Discipline B4(4+2)	OE-4 (3)	L1-4 (3), L2-4(3) (3+1+0 each)	Constitution of India (2)		Sports/NCC/NSS etc. (2) (1+0+2)	25
Exit option with Diploma (96 credits)							
V	**Statistical Inference-II** (3+2) **Matrix Algebra and Regression Analysis** (3+2) Discipline B5(3+2)	DS-B Elective 1 (3)			SEC-3: Cyber Security (2) (1+0+2)	Ethics & Self Awareness (2) (1+0+2)?	20

VI	**Analysis of variance and design of experiments** (3+2) Discipline B6(3+2) Discipline B7(3+2)	DS-A Elective 1 (3)			SEC-4: Professional/ Societal Communication (2)		20
Exit option with Bachelor of Arts, B.A. / Bachelor of Science, B. Sc. Basic Degree (136 credits)							

Summary of Discipline Specific Courses (DSC)			
Semester	**Course Code**	**Title of the Paper**	**Credits**
I	ST 121	Descriptive Statistics	4
	ST 1P1	Practical based on ST 121	2
II	ST 221	Probability and Distributions	4
	ST 2P1	Practical based on ST 221	2
III	ST 321	Calculus and Probability Distributions	4
	ST 3P1	Practical based on ST 321	2
IV	ST 421	Statistical Inference-I	4
	ST 4P1	Practical based on ST 421	2
V	ST 5121	Statistical Inference-II	3
	ST 5P1	Practical based on ST 5121	2
	ST 5221	Matrix Algebra and Regression Analysis	3
	ST 5P2	Practical based on ST 5221	2
VI	ST 6121	Analysis of variance and design of experiments	3
	ST 6P1	Practical based on ST 6121	2

List of Discipline Specific Electives (DSE)	
• Operations Research	• Statistical Quality Control

List of Open Elective (OE) for first four semesters	
• Statistical Methods • Business Statistics • Applied statistics • Biostatistics	• Statistical Methods for Population Studies • Introduction to R Software • An introductory course on Operations Research

Curriculum Structure for the Undergraduate Degree Program: B.Sc.

Total Credits for the Program: 136
Starting year of implementation: 2021-22
Name of the Degree Program: B. Sc.
Discipline/Subject: Statistics (Major)

Program Articulation Matrix

This matrix lists only the core courses. Core courses are essential to earn the degree in that discipline/subject. They include courses such as theory, laboratory, project, internships etc. Elective courses may be listed separately

Semester	Title /Name of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite course(s)	Pedagogy##	Assessment$
1	**Descriptive Statistics**	PO1,PO2,PO 8	Mathematics of 12th level	1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises. 2. Students are encouraged to use resources available on open sources.	The assessment is done using continuous assessment through written test, open book examination, viva-voce, seminars, and group discussions.
1	**Practical**	PO5, PO6	Mathematics of 12th level	The course is taught using Excel software and/or manually to carry out descriptive statistical analysis.	Assessment of learning through experiments
2	**Probability and Distributions**	PO7,PO9,PO 10	Mathematics of 12th level	1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises. 2. Students are encouraged to use resources available on open sources	The assessment is done using continuous assessment through written test, open book examination, viva-voce, seminars, and group discussions.
2	**Practical**	PO5, PO6	Mathematics of 12th level	The course is taught using R programming software and/or manually to carry out descriptive statistical analysis	Assessment of learning through experiments

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/course projects/ problem or project-based learning/ case studies/self-study like seminar, term paper or MOOC

$ Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e., assessment for learning).

Course Pre-requisite(s): II PUC with Mathematics

Course Outcomes (COs)

At the end of the course the student should be able to:

1. Acquire knowledge of introductory statistics, its scope and importance in various areas such as Medical, Engineering, Agricultural and Social Sciences etc.
2. Get knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion etc.
3. Perceive the knowledge of correlation, regression analysis, regression diagnostics, partial and multiple correlations.
4. Learn different of types of data reflecting independence and association between two or more attributes.
5. Develop ability to critically assess a standard report having graphics, probability statements.
6. Conceptualize the probabilities of events including frequentist and axiomatic approach. Simultaneously, they will learn the notion of conditional probability including the concept of Bayes' Theorem,
7. Get knowledge related to concept of discrete and continuous random variables and their probability distributions including expectation and moments,
8. Learn knowledge of important discrete and continuous distributions such as Binomial, Poisson, Normal distributions.
9. Acquire knowledge on R-programming in the descriptive statistics and probability models.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs 1-12)

Course Outcomes (COs) / Program Outcomes (POs)	1	2	3	4	5	6	7	8	9	10	11	12
1. Knowledge of introductory statistics, its scope and importance in various areas such as Medical, Engineering, Agricultural and Social Sciences etc.	X	X			X	X						
2.Knowledge of various types of data, their organization and evaluation of summary measures such as measures of central tendency and dispersion etc.			X	X	X	X				X	X	
3. Knowledge of correlation, regression analysis, regression diagnostics, partial and multiple correlations.				X	X	X		X		X	X	
4.Knowledge of types of data reflecting independence and association between two or more attributes				X	X	X				X		X
5. Develop ability to critically assess a standard report having graphics, probability statements.					X	X	X		X			
6. Knowledge to conceptualize the probabilities of events including frequentist and axiomatic approach. Simultaneously, they will learn the notion of conditional probability including the concept of Bayes' Theorem.					X	X			X	X		
7. Knowledge related to concept of discrete and continuous random variables and their probability distributions including expectation and moments.					X	X			X	X		
8. Knowledge of important discrete and continuous distributions such as Binomial, Poisson, Normal, distributions.					X	X			X	X		
9. Knowledge on R-programming in the descriptive statistics and probability models.					X	X			X	X		

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. 'X' in the intersection cell indicates that particular course outcome addresses that particular program outcome

Bachelor of Science (Basic/Hons.) in Statistics

First Semester

ST – 121: Descriptive Statistics

Semester	I
Paper Code	**ST-121**
Paper Title	**Descriptive Statistics**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04
Formative Assessment Marks	40
Summative Assessment Marks	60

Unit – 1: Introduction to Statistics **13 Hours**

Statistics: Definition and scope. Concepts of statistical population and sample. Data: quantitative and qualitative, cross sectional and time-series, discrete and continuous. Scales of measurement: nominal, ordinal, interval and ratio. Sampling theory concepts: (SRS, Stratified, Systematic and Cluster sampling methods (Definitions only). Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and leaf displays.

Unit – 2: Univariate Data Analysis **18 Hours**

Measures of Central Tendency: Mean, weighted mean, trimmed mean, Median, Mode, Geometric and harmonic means, properties, merits and limitations, relation between these measures. Measures of Dispersion: Range, Quartile deviation, Mean deviation, Standard deviation and their relative measures. Moments, Skewness and Kurtosis. Quantiles and measures based on them. Box Plot. Outliers. Chebyshev's inequality, normal data sets.

Unit – 3: Bivariate Data Analysis **15 Hours**

Bivariate Data, Scatter plot, Correlation, Karl Pearson's correlation coefficient, Rank correlation – Spearman's and Kendall's measures. Concept of errors, Principle of least squares, fitting of polynomial and exponential curves. Simple linear regression and its properties. Fitting of linear regression line and coefficient of determination.

Unit –4: Multivariate Data Analysis **10 Hours**

Analysis of Categorical Data: Contingency table, independence and association of attributes, measures of association - odds ratio, Pearson's and Yule's measure, Multivariate data sets and its visualization, illustration of mean vector and dispersion matrix, Multiple linear regression, multiple and partial correlation coefficients (Only for 3 variables). Residual error variance.

References

1. Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.
2. Anderson T.W. and Jeremy D. Finn (1996). The New Statistical Analysis of Data, Springer
3. Freedman, D., Pisani. R and Purves. R. (2014), Statistics,4th Edition, W. W. Norton & Company.
4. Gupta, S.C. (2018), Fundamental of Statistics, Himalaya Publishing House, 7thEdition.
5. Gupta S.C. and V.K. Kapoor (2020), Fundamental of Mathematical Statistics, Sultan Chand and Co. 12th Edition.
6. Hogg, R. V. McKean J. W. and Craig, A. T. (2012), Introduction to Mathematical Statistics, Pearson 7th Edition.
7. Joao Mendes Moreira, Andre C P L F de Carvalho, Tomas Horvath (2018), General Introduction to Data Analytics, Wiley.
8. Johnson, R.A. and Bhattacharyya, G.K. (2006), Statistics: Principles and methods. 5th Edition, John Wiley & Sons, New York.
9. Medhi, J. (2005), Statistical Methods, New Age International.
10. Ross, S.M. (2014), Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press.
11. Tukey, J.W. (1977), Exploratory Data Analysis, Addison-Wesley Publishing Co. References

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 121**
Title of the paper:		**Introduction to Statistics and Probability**
Unit number	**Number of hrs.**	**Total marks**
1	13	20
2	18	28
3	15	23
4	10	15
Total	55	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: **At the end of the Course, the student should be able to**

CO1	Apply knowledge of statistical concepts and methods to effectively organize and present data using appropriate tabular and graphical techniques.
CO2	Demonstrate the ability to analyze and apply various measures of central tendency and dispersion, including mean, median, mode, standard deviation, and quantiles, as well as interpret data distributions using box plots etc.
CO3	Analyze the relationship between two variables using bivariate data analysis techniques like scatter plots, correlation coefficients, and linear regression and draw meaning conclusions.
CO4	Critically evaluate the relationships between multiple categorical variables using contingency tables and measures of association to identify potential dependencies and interpret their strength.

Practical I

ST – 1P1 – Practical on ST – 121

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel

1. Presentation of data by frequency tables, diagrams and graphs, stem and leaf, partition values.
2. Arithmetic Mean (AM), geometric mean, harmonic mean, weighted AM, trimmed mean, corrected mean.
3. Mode, median, partition values.
4. Absolute and relative measures of dispersion, Box plots.
5. Problems on moments, skewness and kurtosis.
6. Fitting of curves by least squares method.
7. Product moment correlation coefficient and rank correlation.
8. Regression of two variables.
9. Multivariate Descriptive statistics, mean Vector, dispersion matrix correlation matrix, Partial and Multiple correlation.
10. Problems on Association of attributes.

Bachelor of Science (Basic/Hons.) in Statistics
Second Semester
ST 221: Probability and Distributions

Semester	II
Paper Code	**ST-221**
Paper Title	**Probability and Distributions**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit –1: Probability **15 Hours**

Random experiment, sample space and events, algebra of events. Definitions of Probability- Classical, statistical, subjective and axiomatic approaches – illustrations and applications,

Addition Theorem, Conditional probability, independence of events and multiplication Theorem, Total probability rule, Bayes theorem and applications.

Unit –2: Random Variables and Mathematical Expectation **14 Hours**

Definitions of discrete and continuous random variables, Distribution function, probability mass and density functions – properties and illustrations, Expectation of a random variable and Properties of expectation, Moments and moment generating function – properties and uses.

Unit –3: Standard Distributions **16 Hours**

Bernoulli, Binomial, Poisson, Geometric distributions– mean, variance, moments and m. g. f. recursive relations for probabilities and moments of Binomial and Poisson distributions, Uniform, Exponential and Normal distribution: Mean and Variance, m. g. f. Memoryless property, Area property of normal distribution. Fitting of distributions and to assessing its goodness of fit (Graphically).

Unit –4: Data Analysis Using R **11 Hours**

Introduction to R: Installation, command line environment, overview of capabilities, brief mention of open-source philosophy. R as a calculator: The four basic arithmetic operations. Use of parentheses nesting up to arbitrary level. The power operation. Evaluation of simple expressions. Quotient and remainder operations for integers. Standard functions, e.g., sin, cos, exp, log. The different types of numbers in R: Division by zero leading to Inf or -Inf. NaN. NA. No need to go into details. Variables. Creating a vector using c(), seq() and colon operator. How functions map over vectors. Functions to summarize a vector: sum, mean, sd, median etc. Extracting a subset from the vector (by index, by property). R as a graphing calculator: Introduction to plotting. Plot(), lines(), abline(). No details about the graphics parameters except colour and line width. Barplot, Pie chart and Histogram. Box plot. Scatter plot and simple linear regression using lm(y~x). Problems on discrete and continuous probability distributions

References

1. Dudewitz. E.J. and Mishra. S. N. (1998), Modern Mathematical Statistics. John Wiley.
2. Goon A.M., Gupta M.K., Das Gupta. B. (1991), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
3. Gupta. S.C and V.K. Kapoor (2020), Fundamentals of Mathematical Statistics, Sultan Chand and Co, 12th Edition.
4. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009), Probability and Statistical Inference, Seventh Edition, Pearson Education, New Delhi.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007), Introduction to the Theory of Statistics, 3rd Edition. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.
6. Ross, S. (2002), A First Course in Probability, Prentice Hall.
7. Sudha G. Purohit, Sharad D. Gore, Shailaja R Deshmukh, (2009), Statistics using R, Narosa Publishing House.
8. R for beginners by Emmanuel Paradis (freely available at https://cran.rproject.org/doc/contrib/Paradisrdebuts_en.pdf)
9. Venables W.N., Smith D.M., and the R-development core team, An Introduction to R.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 221**
Title of the paper:		**Probability and Distribution**
Unit number	**Number of hrs.**	**Total marks**
1	15	23
2	14	21
3	16	25
4	11	17
Total	56	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: **At the end of the Course, the student should be able to**

CO1	Explain the fundamental concepts of probability theory, including random experiments, sample spaces, events, different approaches to defining probability (classical, statistical, subjective, axiomatic), and their applications in various scenarios.
CO2	Analyze the characteristics of random variables (discrete or continuous) using probability distributions, calculate expected values and interpret moments and moment generating functions to understand the central tendency and spread of data.
CO3	Apply their knowledge of common probability distributions (Bernoulli, Binomial, Poisson, Uniform, Exponential, Normal) to real-world scenarios by identifying the appropriate distribution based on data characteristics and fitting the distribution to the data.
CO4	Use R programming to perform basic data analysis tasks, including creating and manipulating data structures (vectors), calculating summary statistics, and generating informative visualizations (plots, histograms, scatter plots) to explore and understand data.

Practical II

ST – 2P1 – Practical on ST – 221

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Two exercises on Descriptive statistics (Presentations, Summarizations, correlations, regression and Graphs using R)
2. Computing probability: using addition and multiplication theorems.
3. Conditional probability and Bayes' theorem.
4. Problems on pmf, expectation, variance, quantiles, skewness, kurtosis (Discrete Case).
5. Problems on pdf, expectation, variance, quantiles, skewness, kurtosis (Continuous case).
6. Problems on discrete probability distributions (Binomial, Poisson, Geometric)
7. Problems on Uniform, Exponential and Normal probability distributions
8. Computation of moments and Moment generating functions (Discrete and Continuous Case).
9. Fitting of distributions (Binomial, Poisson, Geometric, Uniform, Exponential, Normal)
10. Generation of random samples. (Binomial, Poisson, Geometric, Uniform, Exponential, Normal)

Bachelor of Science (Basic/Hons.) in Statistics

Third Semester

ST 322: Calculus and Probability Distributions

Semester	III
Paper Code	**ST-322**
Paper Title	**Calculus and Probability Distributions**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit –1: Limits, Continuity, and Differentiability. 10 Hours

Introduction to Sets and functions, types of functions, properties of functions, Monotonicity, convexity and concavity, Bounded functions. recapitulation and extension of limits and continuity, differentiability. Limit inferior and Limit superior, L'Hopital's rule, mean value theorems (Lagrange and Cauchy's) with examples, Taylor's Theorem, Maclaurin's series with the application. (Statement only), Introduction to nth derivative.

Unit –2: Sequences, Series, and Integration 12 Hours

Sequences and series of real numbers, Bounded sequences, Convergent and divergent sequences, Limit of sequences with their properties.

Series – Definition of infinite series, tests for convergence of infinite series - properties of series of positive terms - Geometric series Tests for convergence of series -p- series - comparison of series Cauchy's root Test -D Alembert's test. Raabe's test

Introduction to proper and Improper Integrals, types of improper Integrals, evaluation of improper Integrals, Beta and Gamma Integrals with their properties. –Maxima and Minima of functions of two variables. Method of Lagrange multipliers.

Unit –3: Basics of Sampling and Exact sampling distributions. 12 Hours

Concepts of population and sample. Sampling distributions and Standard error of a statistic and its uses. Sampling distribution of the sample means, sample variance, and their independence under normality assumption. Chi- square, t, and F statistic under normality assumption. Generation of random numbers from standard distributions.

Unit – 4: Discrete and Continuous Probability distributions and their applications. 22 Hours

Negative-Binomial, Hypergeometric distributions- Definitions through p.m.f's, mean, variance, moments, and MGF. Limiting form of Hypergeometric and Binomial distributions, relationship between geometric and Negative binomial distributions.

Gamma, Beta (First and Second kind), Laplace and Cauchy distributions – definition through p.d.f.s. Mean, variance, moments, and MGF with their properties.

Applications of discrete and continuous distribution through real life examples.

Chi-square, t and F distributions- Definitions through p.d.f's, mean, variance properties and uses.

References

1. Ghorpade.S.R., and Limaye. B.V., (2006): A course in Calculus and Real Analysis, Springer Series, New York.
2. Ajith Kumar and S. Kumaresan., (2014): A basic course in Real Analysis, CRC Press, Taylor and Francis, United Kingdom.
3. Shanti Narayan and Mittal. P.K., (2005): A course of Mathematical Analysis, S. Chand Publishers, New Delhi.
4. Rohatgi. V.K. and A.K. Md. Ehsanes Saleh (2002). An Introduction to Probability theory and Mathematical Statistics. John Wiley. (WSE)
5. Bhattacharya and N.L. Johnson (1986): Statistical concepts. John Wiley.
6. Miller. I and Miller. M (2014) John E. Freund's Mathematical Statistics with Applications, Pearson.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 322**
Title of the paper:		**Calculus and Probability Distribution**
Unit number	**Number of hrs.**	**Total marks**
1	10	15
2	12	18
3	12	18
4	22	35
Total	56	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Apply the concepts of limits, continuity, and differentiability to analyze real-valued functions
CO2	Employ their understanding of sequences, series, and integration to solve various mathematical problems
CO3	Understand the importance of sampling and sampling distributions and their practical implications.
CO4	Demonstrate the specific applications to various discrete and continuous probability distributions through real life examples.

Practical III

ST – 3P1 – Practical on ST – 322

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Practical on Sequences and Series
2. Numerical evaluation of some special functions.
3. Drawing random samples and construction of sampling distribution of sample mean and sample variance
4. Drawing random samples and construction of sampling distribution of sample mean and sample variance (using MS Excel and R)
5. Applications of Negative binomial distribution and Hypergeometric (Computation of probabilities, fitting)
6. Fitting Negative Binomial, Hypergeometric using MS Excel and R
7. Computation of probabilities and plotting pmf, cdf using MS-Excel and R (Negative Binomial, Hypergeometric)
8. Computation of probabilities and plotting pdf, cdf using MS-Excel and R (Gamma, Beta, Cauchy, Laplace)
9. Generation of random observations from standard discrete distributions
10. Generation of random observations from standard continuous distributions

Bachelor of Science (Basic/Hons.) in Statistics

Fourth Semester

ST 422: Statistical Inference - I

Semester	IV
Paper Code	**ST-422**
Paper Title	**Statistical Inference - I**
Number of teaching hours per week	04
Total number of teaching hours per semester	56
Number of credits	04
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit -1: Family of Distributions and Theory of Point Estimation: 18 Hours

Family of distributions: Power Series family, single parameter exponential family, K - parameter exponential family, location - Scale family, Pitman family Definitions, examples and applications with case studies.

Point Estimation - Concepts of estimator and estimate, criteria of a good estimator - Unbiasedness, Consistency, sufficient conditions for consistency, Invariance property of consistent estimator, Sufficient Statistic - Statement of Neyman – Factorization theorem, minimum variance unbiased estimator, Efficiency and Relative efficiency, mean square error. (Problems on estimation from Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Uniform, Normal and Exponential distributions only).

Unit -2: Methods of Point Estimation: 12 Hours

Methods of Point Estimation: Maximum likelihood estimator (MLE) and method of moments: Properties, Illustration for non-uniqueness and invariance property of MLE. Estimation of parameters for Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Normal, Exponential, Continuous Uniform distributions.

Unit - 3: Interval Estimation: 14 Hours

Confidence Interval, Confidence coefficient, Pivotal quantity method of constructing Confidence Intervals, construction of confidence intervals for the mean, the difference between two means, variance and ratio of variances, proportion, the difference between proportions, and correlation coefficient.

Unit - 4: Testing of Hypotheses: 12 Hours

Definition of Statistical hypotheses and types - null and alternative, simple and composite hypotheses. Type-I and Type-II Errors, size of the test, level of significance, power of the test, and power function. Test function, Randomized and non-randomized test (definition only). Critical region. P-value, its interpretation. Illustration for a large sample test of the single mean.

References:

1. Freund J.E. (2001): Mathematical Statistics, Prentice Hall of India.
2. Goon A.M., Gupta M.K., Das Gupta.B. (1991): Fundamentals of Statistics, Vol. I, World Press, Calcutta.
3. Hogg R.V. and Tannis E.A. (1988): Probability and Statistical Inference, Collier MacMillan.
4. Hodges J.L and Lehman E.L (1974): Basic Concepts of Probability and Statistics, Holden-Day.
5. Mood A.M, Graybill F.A and Boes D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
6. Gupta. S.C. and V.K.Kapoor (2001): Fundamentals of Mathematical Statistics. Sultan Chand & Co.
7. Bhattacharya and Johnson (1986): Statistical Concepts, Wiley Int. Ed.
8. Rohatgi. V.K. and A.K. Md. Ehsanes Saleh (2002). An Introduction to Probability theory and Mathematical Statistics. John Wiley (WSE).
9. Ross S.M: Introduction to Probability and Statistics., John Wiley & Sons

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 422**
Title of the paper:		**Statistical Inference - I**
Unit number	**Number of hrs.**	**Total marks**
1	18	28
2	12	18
3	14	22
4	12	18
Total	56	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Describe the family of distributions, including the power series family, single-parameter exponential family and explain their applications with case studies.
CO2	Apply the concepts of point estimation to standard distributions, such as estimating parameters from Bernoulli, Poisson, Normal, Exponential distributions, etc.
CO3	Acquire the concept of confidence intervals to estimate population parameters based on sample data.
CO4	Apply estimation methods and concepts of hypothesis testing to analyze real-world datasets and draw meaningful conclusions.

Practical IV

ST – 4P1 – Practical on ST – 422

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Properties of estimators on unbiasedness, consistency and efficiency.
2. Comparison of estimators by plotting mean square error using MS-Excel and R.
3. Estimation of parameters by Maximum Likelihood method.
4. Estimation of parameters by Method of Moments.
5. Estimation of parameters by Maximum Likelihood method and Method of Moments (Using Software).
6. Construction of confidence intervals - I (large samples).
7. Construction of confidence intervals - II (small samples).
8. Construction of confidence intervals using R & MS-Excel.
9. Testing of Hypothesis - I (Formulation of hypotheses, understanding types of hypotheses, understanding types of tests).
10. Testing of Hypothesis - II (Understanding Type I error and Type II Error)

Bachelor of Science (Basic/Hons.) in Statistics

Fifth Semester

ST 5122: Statistical Inference - II

Semester	V
Paper Code	**ST-5122**
Paper Title	**Statistical Inference – II**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit – 1: MP and UMP tests **16 Hours**

Most Powerful (MP) test. Statement of Neyman – Pearson Lemma and its applications. MP test for parameters of Bernoulli, Binomial and Normal distributions.

Monotone likelihood ratio (MLR) property. Uniformly most powerful (UMP) test. Statement of the theorem on UMP test for testing one-sided hypothesis for distributions with MLR property. (Only parameter of Bernoulli and mean of Normal Distribution)

Unit – 2: Likelihood Ratio tests **6 Hours**

Likelihood ratio tests (LRT) and its properties. LRTs for mean and variance of normal distribution (one-sample problem), LRT for the mean of Exponential distribution.

Unit -3: Tests of Significance: **10 Hours**

Large and small sample tests of significance. Tests for proportions and differences between proportions, Tests for single mean, equality of two means, single variance, and the ratio of two variances. Tests for correlation coefficient and regression coefficients (only slope and intercept (t-test)). Fisher's Z-transformation and its applications (test for non-zero correlation coefficient). Analysis of categorical data- contingency table, Chi-square test for independence of attributes in a contingency table, Chi-square test for goodness of fit, and equality of several proportions using Chi-square test.

Unit – 4: Non-Parametric tests: **10 Hours**

Need for distribution-free tests - non-parametric tests. one sample and two samples sign tests, Wilcoxon signed-rank test, Median test, Wald Wolfowitz run test, Mann Whitney Wilcoxon test, run test for randomness, test for independence based on Spearman's rank correlation coefficient (small and large samples), Kolmogorov-Smirnov one-sample test and two-sample test, Normal probability plot and QQ Plot.

Reference:

1. Rohatgi. V.K. and A.K. Md. Ehsanes Saleh (2002). An Introduction to Probability theory and Mathematical Statistics. John Wiley (WSE).
2. Hogg R.V. and Tannis E.A. (1988): Probability and Statistical Inference, Collier MacMillan.
3. Mukhopadhyay. P (1996). Applied Statistics. Calcutta Publishing House.
4. Gupta. S.C. and V.K.Kapoor (2001): Fundamentals of Mathematical Statistics. Sultan Chand & Co.
5. Gopal K. Kanji (2006), 100 Statistical tests, 3rd Edition, Sage Publications
6. Purohit S.G. et.al. Statistics using R
7. Dudewicz. E.J. and Mishra. S.N. (1980). Modern Mathematical Statistics. John Wiley.
8. Kale B.K (2005) A First Course on Parametric Inference, the Narosa 2nd Edition.
9. Randles R.H and Wolfe DA (1979): Introduction to the Theory of nonparametric Statistics, John Wiley
10. John Verzani (2005): Using R for Introductory Statistics, CHAPMAN & HALL/CRC
11. Venables W.N., Smith D.M., and the R-development core team, An Introduction to R

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 5122**
Title of the paper:		**Statistical Inference – II**
Unit number	**Number of hrs.**	**Total marks**
1	16	33
2	06	12
3	10	21
4	10	20
Total	42	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Understand and apply the concepts of MP and UMP tests for standard distributions.
CO2	Explain the concept of likelihood ratio test and its importance.
CO3	Apply the statistical inference tools in real data analysis.
CO4	Understand and apply the concept of nonparametric tests to analyze data when the assumptions of normality for parametric tests are not met.

Practical V

ST – 5P1 – Practical on ST – 5122

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. MP test, UMP test and LR test for parameters of Bernoulli distribution & Normal Distributions
2. Tests concerning means and proportions (small and large sample)
3. Tests concerning variances (small and large sample)
4. Tests for correlation coefficients and Regression coefficient (slope and intercept)
5. Tests for Independence of attributes and equality of many proportions
6. Tests for goodness of fit. (Uniform, Binomial, Poisson and Normal)
7. Small and Large sample test using MS Excel and R
8. Nonparametric tests – 1 (for single and related samples)
   (sign test and Wilcoxon signed rank, test, Kolmogorov Smirnov test and one sample runs test)
9. Nonparametric tests – 2 (for two independent samples)
   (Median test, Wilcoxon Mann Whitney – U test, Wald - Wolfowitz's runs test)
10. Tests for Normality, Histogram, QQ Plot using R

Bachelor of Science (Basic/Hons.) in Statistics

Fifth Semester

ST 5222: Matrix Algebra and Linear Regression

Semester	V
Paper Code	**ST-5222**
Paper Title	**Matrix Algebra and Linear Regression**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit- 1: Vector Spaces and Matrices **10 Hours**

Transpose, determinant, inverse, rank, and the trace of a matrix, Hassenberg matrix

Vector spaces, and subspaces, examples of vector spaces on R, basis and dimension of a vector space, rank nullity theorem

Linear independence of vectors, inner product and orthogonal vectors, Gram-Schmidt orthogonalization process (Concept only)

Unit- 2: Eigen Values and Eigen Vectors **8 Hours**

Eigenvalues and Eigenvectors, Cayley-Hamilton theorem, algebraic and geometric multiplicities, rank multiplicity theorem. Quadratic forms, congruent transformations, congruence of symmetric matrices, canonical reduction and orthogonal reduction of real quadratic forms, nature of quadratic forms, simultaneous reduction of quadratic forms.

Unit- 3: Simple and Multiple Regression **12 Hours**

Simple linear regression and Multiple Linear Regression Models: Assumptions, Least-squares estimates and their properties, Model fitting, residuals, Coefficient of determination. Tests for significance of regression, tests on individual regression coefficients. Confidence intervals in multiple linear regression and prediction of a new observation.

Unit- 4: Model Adequacy **12 Hours**

Different methods of variable selections – forward, backward, step-wise (only concept), Model Adequacy – Residual Analysis, tests for normality – QQ Plot. Introduction to Heteroscedasticity, Multicollinearity, and Autocorrelation, measures of identifying above situations, and remedial measures. Introduction to logistic regression

Reference:

1. Graybill F. A. (1969): An Introduction to Linear Statistical Models.
2. S. Kumaresan (2000) Linear Algebra: A Geometric Approach, PHI
3. Draper N. R. and Smith H. (2003): Applied Regression Analysis, 3rd Ed., John Wiley.
4. Hosmer D. N. and Lemeshow's (2013): Applied Logistic Regression, 3rd Ed., John Wiley.
5. Montgomery D. C., Peck E. A. and Vining G. G.(2003): Introduction to Linear regression Analysis, 3rd Ed., John Wiley.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 5222**
Title of the paper:		**Matrix Algebra and Linear Regression**
Unit number	**Number of hrs.**	**Total marks**
1	10	20
2	8	16
3	12	25
4	12	25
Total	42	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Understand the basic concepts of matrix algebra, such as determinants, inverse, rank etc and apply these tools in problem solving.
CO2	Analyze the properties of eigenvalues and eigenvectors of matrices and quadratic forms to solve problems and gain insights into their behavior.
CO3	Understand the theoretical foundations of linear regression analysis, including the assumptions underlying the model and apply this to real life datasets.
CO4	Evaluate the validity of regression models and diagnose issues such as multicollinearity, heteroscedasticity, and autocorrelation

Practical VI

ST – 5P2 – Practical on ST – 5222

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Linear Independence and Linear dependence of a set of vectors.
2. Determinants, Inverse and Rank of a matrix.
3. Verification of Cayley-Hamilton theorem. Eigenvalues and Eigenvectors of a matrix.
4. Simple linear regression
5. Multiple linear regression
6. Fitting Regression model for Multivariate Data using MS-Excel and R
7. Regression analysis Model Adequacy-Residual Analysis, t-test, and F-test
8. Regression analysis with Multicollinearity and variable selection techniques.
9. Regression analysis with Heteroscedasticity.
10. Regression analysis with Autocorrelation

Bachelor of Science (Basic/Hons.) in Statistics

Sixth Semester

ST 6122: Analysis of Variance and Design of Experiment

Semester	VI
Paper Code	**ST-6121**
Paper Title	**Analysis of Variance and Design of Experiment**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit- 1: Understanding designs **5 Hours**

Experimental designs: Role, historical perspective, terminology: Treatments, Experimental units & Blocks, Experimental error, Basic principles of Design of Experiments. Randomization - Blinded experiments. Uniformity trials, fertility contour maps, choice of size and shape of plots and blocks in Agricultural experiments. Real-time industrial application with case studies.

Unit – 2: Analysis of Variance **12 Hours**

Analysis of Variance: Definition and assumptions. Analysis of variance - fixed-effects and random-effects models. Analysis of one-way and two-way classified data, testing of hypothesis, and ANOVA tables. Multiple comparison tests-Least significant difference, Tuckey's test.

Unit-3: Design of Experiment: **15 Hours**

Implementation of Basic principles of design. Completely randomized design, randomized block design, and Latin square design - assumptions, layout, model, derivation of least squares estimates of parameters, hypotheses testing, and ANOVA table.

The efficiency of RBD over CRD and LSD over RBD. Missing plot technique- Estimation of single missing observation in RBD and LSD, analysis.

Unit-4: Factorial Experiments: **10 Hours**

Concept of factorial designs - 2^2 and 2^3 factorial experiments - Main effects and interactions. Their best Estimates, orthogonal contrasts. Yates's method of computing factorial effect totals. Complete and partial confounding in 2^3-factorial experiments - analysis when the underlying design is RBD.

Reference:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.
6. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
7. Dean, A.M. and Voss, D. (1999): Design and Analysis of Experiments. Springer Texts in Statistics.

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**ST – 6122**
Title of the paper:		**Analysis of Variance and Design of Experiment**
Unit number	**Number of hrs.**	**Total marks**
1	5	10
2	12	25
3	15	31
4	10	20
Total	42	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Identify the different types of effect models and to set up the analysis of variance for one-way and two-way models with various effect models.
CO2	**Apply** analysis of variance (ANOVA) techniques to analyze data from one-way and two-way classified experiments, interpret the results using ANOVA tables, and conduct post-hoc multiple comparison tests.
CO3	Analyze and compare the efficiency of different experimental designs (completely randomized, randomized block, and Latin square) by applying statistical principles, conducting hypothesis testing, and interpreting ANOVA tables.
CO4	Critically evaluate the effects (main and interaction) within a factorial experiment and explain their implications and also able to identify potential confounding factors and adjust their analysis accordingly.

Practical VII

ST – 6P1 – Practical on ST – 6122

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Completely Randomized Design & Analysis of one-way classification data
2. Randomized Block Design & Analysis of two-way classification data
3. Analysis of one way and two-way classification data using MS Excel and R
4. Latin Square Design
5. Multiple comparison tests
6. Missing plot techniques
7. Analysis of 2^2 factorial experiments using RBD layout.
8. Analysis of 2^3 factorial experiments using RBD layout.
9. Analysis of 2^3 factorial experiments using RBD layout. (Complete confounding)
10. Analysis of 2^3 factorial experiments using RBD layout. (Partial confounding)

Bachelor of Science (Basic/Hons.) in Statistics
Sixth Semester
STDE A – 6222: Statistical Methods for Quality Management

Semester	VI
Paper Code	**STDE A – 6221**
Paper Title	**Statistical Methods for Quality Management**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit-1: Basics of Statistical Quality Control: 09 Hours

Introduction-quality, quality control, Quality assurance, quality costs. Seven QC tools. Chance and assignable causes of variation. Introduction to quality standards –BIS and ISO, Six-sigma and Total Quality Management, Deming's 14-point principles. Statistical Quality Control (SQC) -. Aims and objectives, Process control and product control. Control charts and basis for its construction, Probability and k sigma limits, action and warning limits. Rational subgroups.

Unit-2: Control Charts for variables and attributes: 11 Hours

Derivation of control limits, construction and interpretation of mean, range and standard deviation charts. Revised control charts. Criteria for detecting lack of control, OC and ARL for mean and range charts. Need for control charts for attributes, derivation of control limits, basis, construction and interpretation of np-chart, p-chart, stabilized p-chart, c-chart, u-chart and their applications.

Unit-3: Process Capability: 07 Hours

Natural tolerance limits and specification limits. Process capability study-process capability and Process capability ratio Cp, Cpk, Cpm. Acceptance sampling-Introduction. Sampling inspection, 100 percent inspection and Rectifying inspection. AQL, LTPD, Producer's risk and consumer's risk.

Unit- 4: Lot Acceptance Sampling: 15 Hours

Acceptance Sampling plans – single and double sampling plans by attributes. Derivation of O.C, A.O.Q, A.S.N and A.T.I, functions for single and double sampling plans. Construction of single sampling plans by attributes given AQL, LTPD, producer's risk, consumer's risk. Sequential Probability Ratio Test; concept and operational definition. Determination of stopping bounds A and B, OC and ASN functions of SPRT for testing the mean of a normal distribution with known variance. Statement of the optimal property of SPRT.

Reference:

1. Grant, E.L and Leavenworth,R.S (1988): Statistical Quality control. 6th edition, McGrawHill.
2. Gupta,R.C: Statistical Quality control. (Khanna Pub. Co.)
3. Montgomery,D.C (1985): Introduction to Statistical Quality control. (Wiley Int. Edn.)
4. Goon,A.M et.al.: Fundamentals of Statistics Vol II (World Press, Calcutta
5. Gupta,S.C and V.K. Kapur: Fundamentals of Applied Statistics. (Sultan Chand and Co.)
6. John, S.Oakland and Followell,R.F (1990): Statistical Process Control. (East West Press, India)
7. Wetherill,G.B and D.W.Bfown: Statistical Process Control theory and practice. (Chapman and Hall)
8. Mahajan,M (2001): Statistical Quality Control. Dhanpat Rai & Co. (P) Ltd.
9. Donne,C.S. (1997): Quality. Prentice Hall.
10. Sinha S.K. and Kale B.K.(1980) Life testing and Reliability (New age)
11. Duncan A.J (1974): Quality Control and Industrial Statistics, Taraporewala and Sons.
12. John Verzani (2005): Using R for Introductory Statistics, CHAPMAN & HALL/CRC
13. Issa Bass (2007), Six Sigma Statistics with EXCEL and MINITAB, McGraw Hill
14. Ruth K. Meyer, David D. Krueger, (1998), A Minitab Guide to Statistics, Prentice Hall,
15. https://cran.r-project.org/web/packages/qcc/qcc.pdf

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**STDE A – 6222**
Title of the paper:		**Statistical Methods for Quality Management**
Unit number	**Number of hrs.**	**Total marks**
1	9	18
2	11	23
3	7	14
4	15	31
Total	42	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Understand the concept and application of statistics in industrial environment.
CO2	Acquire knowhow on manufacturing process changes and process variability.
CO3	Analyze and evaluate the effectiveness of a manufacturing process by applying the principles of process capability and acceptance sampling demonstrating their proficiency in the context of quality management.
CO4	Instruct theory and practice of product control methodology.

Practical VIII

ST 6P2 – Practical on STDE A – 6222

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. $\bar{X}$– R Charts (Standard values known and unknown)
2. $\bar{X}$– S Charts (Standard values known and unknown)
3. np and p charts. (Standard values known and unknown).
4. C and U charts. (Standard values known and unknown).
5. $\bar{X}$ – R and $\bar{X}$ – s charts (Using Software)
6. np, p, C and U charts (Using Software)
7. OC and ARL curves for $\bar{X}$ and R charts.
8. Construction of single sampling plans by attributes
9. Drawing OC, AOQ, ASN, and ATI curves
   (Both single sampling plans and double sampling plans)
10. Sequential Probability Ratio Test

Bachelor of Science (Basic/Hons.) in Statistics
Sixth Semester
STDE B – 6222: Operations Research

Semester	VI
Paper Code	**STDE B – 6222**
Paper Title	**Operations Research**
Number of teaching hours per week	03
Total number of teaching hours per semester	42
Number of credits	03
Formative Assessment Marks:	40
Summative Assessment Marks:	60

Unit-1: Introduction to O.R and L.P.P, T.P., and A.P.: 17 Hours

Definition and scope of operations research (OR). Modeling and solution.

Linear programming problem (L.P.P) – Definition, Standard and canonical forms. Formulation of LPP. Basic solutions, Degenerate and non-degenerate solution. Fundamental theorem of LPP. Graphical solution and Simplex algorithm for solving an LPP, Criteria for unbounded, multiple and infeasible solutions. Artificial variable, Charnes' Big- M Method.

Transportation problem: Mathematical formulation, finding an initial basic feasible solution by North West corner rule, and Vogel's method. Test for optimality by U – V method, Transportation algorithm (MODI method). Problem of degenerate solution and its resolution.

Assignment problem*:* Mathematical formulation and Hungarian algorithm, Job sequencing, optimal sequence of N jobs on two and three machines.

Unit-2: Statistical Decision Theory and Game theory: 07 Hours

Statistical decision problem and essential elements. Decision making under uncertainty and risk. Game theory- Basic concepts. Two-person zero sum game, Pure and mixed strategies. Maximin–Minimax principle, Gameswith saddle point. Principle of dominance. Games without Saddle point. -mixed strategies, Determination of optimum solution for (2x2) game. Solution by graphical method for (2xn) and (mx2) games.

Unit-3: Network analysis and Inventory Theory: 13 Hours

Basic elements of Network, Drawing of project network. Project planning with CPM and PERT. Critical path calculation. Critical path, slack time, floats. PERT three estimate approach. Calculation of probabilities of completing a Project within a specified period.

Description of an inventory system, Inventory costs. Demand, lead time and reorder level. Inventory models. EOQ model with and without shortages, P – system and Q – system of Inventory

Unit-4: Queuing theory: 05 Hours

Basic elements, description of a queuing system and measures of effectiveness. statement of steady state solution of M/M/1 queuing system. Waiting time distributions. Little's formula. Derivation of expressions for Queue length, and system size(length) and waiting times. Description of M/M/C queuing system.

References:

1. Kanthiswarop, Manmohan and P.K. Gupta (2003) Operations Research. Sultan Chand & Co.
2. S D Sharma, Operations Research: Theory and Applications, (2009), Fourth Edition,
3. Churchman, C.W, Ackoff, R.L and Arnoff, E.L. (1957): Introduction to Operations Research. John Wiley.
4. S. D. Sharma, R. K. Malhotra, Operations Management,
5. Shenoy, G.V., Srivastava, U.K and Sharma, S.C: Operations Research for management. New Age Publications.
6. Kalavathy S - Operations Research (Vikas Publishers)
7. Mustafi, C.K. Operations Research methods and practice. New Age. Pub.
8. Mital, K.V. Optimization method. New Age Pub.
9. Narag. A. S. Linear Programming and Decision making. Sultan Chand & Co.
10. Kapoor, V. K. Operations Research. Sultan Chand & Co.
11. N. D. Vohra: Quantitative Techniques in Management (Tata McGraw Hill)
12. John Verzani (2005): Using R for Introductory Statistics, CHAPMAN & HALL/CRC

Pedagogy

1. The course is taught using traditional chalk and talk method using problem solving through examples and exercises.
2. Students are encouraged to use resources available on open sources.

MODEL BLUEPRINT		
Code number:		**STDE B – 6222**
Title of the paper:		**Operations Research**
Unit number	**Number of hrs.**	**Total marks**
1	17	35
2	7	14
3	13	27
4	5	10
Total	42	86
Maximum marks for the paper (Excluding bonus questions)		60

Course Outcomes: At the end of the Course, the student should be able to

CO1	Understand the fundamental concepts of Operations Research (OR), including its definition and scope.
CO2	Analyze and solve statistical decision problems under uncertainty and risk, as well as apply basic concepts of game theory to determine optimal strategies.
CO3	Use network analysis tools to schedule and manage projects effectively and also implement appropriate inventory models to minimize costs and maintain optimal stock levels.
CO4	Understand the fundamental concepts of queuing theory and to explain the core concepts and their applications in analyzing waiting line situations.

Practical VIII

ST – 6P2 – Practical on STDE B – 6222

Number of teaching hours per week	04
Total number of teaching hours per semester	52
Number of credits	02
Formative Assessment Marks	25
Summative Assessment Marks	25

Computing all the practical manually and using Excel/R

1. Formulation of Linear programming problem (L.P.P) and Graphical solution
2. Solution of L.P.P – Using simplex algorithm.
3. Solution of L.P.P – Using Big M Method
4. Transportation Problem
5. Assignment Problems and Job Sequencing
6. Decision theory problems.
7. Game theory problems.
8. PERT and CPM
9. Queuing Problems
10. Inventory problems

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