AC/I(21-22).2(II).RUS11

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for

Program: B.Sc.

Program Code: (STATISTICS) RUSSTA

(Choice Based Credit System for the academic year 2022–2023)

PROGRAM OUTCOMES

S. P. Mandali's Ramnarain Ruia Autonomous College has adopted the Outcome Based Education model to make its science graduates globally competent and capable of advancing in their careers. The Bachelors Program in Science also encourages students to reflect on the broader purpose of their education.

PO	PO Description **A student completing Bachelor's Degree in Science program will be able to:**
PO 1	Recall and explain acquired scientific knowledge in a comprehensive manner and apply the skills acquired in their chosen discipline. Interpret scientific ideas and relate its interconnectedness to various fields in science.
PO 2	Evaluate scientific ideas critically, analyse problems, explore options for practical demonstrations, illustrate work plans and execute them, organise data and draw inferences.
PO 3	Explore and evaluate digital information and use it for knowledge upgradation. Apply relevant information so gathered for analysis and communication using appropriate digital tools.
PO 4	Ask relevant questions, understand scientific relevance, hypothesize a scientific problem, construct and execute a project plan and analyse results.
PO 5	Take complex challenges, work responsibly and independently, as well as in cohesion with a team for completion of a task. Communicate effectively, convincingly and in an articulate manner.
PO 6	Apply scientific information with sensitivity to values of different cultural groups. Disseminate scientific knowledge effectively for upliftment of the society.
PO 7	Follow ethical practices at work place and be unbiased and critical in interpretation of scientific data. Understand the environmental issues and explore sustainable solutions for it.
PO 8	Keep abreast with current scientific developments in the specific discipline and adapt to technological advancements for better application of scientific knowledge as a lifelong learner.

PROGRAM SPECIFIC OUTCOMES

PSO	Description **A student completing Bachelor's Degree in Science program in the subject of Statistics will be able to:**
PSO 1	Understand, condense, visualize, analyze and interpret the data collected in daily walk of life.
PSO 2	Understand the data generated in various scenarios of scientific, industrial, or social problems.
PSO 3	Pursue their higher education programs leading to post-graduate or doctoral degrees.
PSO 4	Enhance knowledge of Statistical tools.
PSO 5	Enhance the theoretical rigor with technical skills which prepare them to become globally competitive to enter into a promising professional life after graduation.
PSO 6	Make a pathway to a range of traditional avenues in Academia and Industry , Govt. Service, IAS, Indian Statistical/ Economic Services, Industries, Commerce, Investment Banking, Banks and Insurance Sectors, CSO and NSSO, Research Personnel/Investigator in Govt. organizations such as NCAER, IAMR, ICMR, Statistical and Economic Bureau & various PSUs., Market Research, Actuarial Sciences, Biostatistics, Demography etc.
PSO 7	Seek employment in different sectors like Stock trading, Sports, Politics, Business, Financial services and Media Industry.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
FYBSc	I	RUSSTA101 (CORE COURSE)	DESCRIPTIVE STATISTICS - I	2
FYBSc	I	RUSSTA102 (CORE COURSE)	STATISTICAL METHODS - I	2
FYBSc	I	RUSSTAP101 (CORE COURSE)	Practical based on RUSSTA101 & RUSSTA102	2
FYBSc	II	RUSSTA201 (CORE COURSE)	DESCRIPTIVE STATISTICS - II	2
FYBSc	II	RUSSTA202 (CORE COURSE)	STATISTICAL METHODS – II	2
FYBSc	II	RUSSTAP201 (CORE COURSE)	Practical based on RUSSTA201 & RUSSTA202	2
SYBSc	III	RUSSTA301	PROBABILITY DISTRIBUTIONS	2
SYBSc	III	RUSSTA302	THEORY OF SAMPLING	2
SYBSc	III	RUSSTA303	OPERATIONS RESEARCH	2
SYBSc	III	RUSSTAP301	Practical based on RUSSTA301, RUSSTA302 & RUSSTA303	3
SYBSc	IV	RUSSTA401	PROBABILITY AND SAMPLING DISTRIBUTIONS	2
SYBSc	IV	RUSSTA402	ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS	2
SYBSc	IV	RUSSTA403	PROJECT MANAGEMENT AND INDUSTRIAL STATISTICS	2
SYBSc	IV	RUSSTAP401	Practical based on RUSSTA401,	3

			RUSSTA402 and RUSSTA403	
TYBSc	V	RUSSTA501	PROBABILITYAND DISTRIBUTIONTHEORY	2.5
TYBSc	V	RUSSTA502	THEORY OF ESTIMATION	2.5
TYBSc	V	RUSSTAP501	Practical based on RUSSTA501 & RUSSTA502	3
TYBSc	V	RUSSTA503	BIOSTATISTICS	2.5
TYBSc	V	RUSSTA504	ELEMENTS OF ACTUARIAL SCIENCE	2.5
TYBSc	V	RUSSTAP502	Practical based on RUSSTA503 & RUSSTA504	3
TYBSc	VI	RUSSTA601	DISTRIBUTIONTHEORY AND STOCHASTIC PROCESSES	2.5
TYBSc	VI	RUSSTA602	TESTING OF HYPOTHESES	2.5
TYBSc	VI	RUSSTAP601	Practical based on RUSSTA601 & RUSSTA602	3
TYBSc	VI	RUSSTA603	APPLIED STATISTICS-I	2.5
TYBSc	VI	RUSSTA604	APPLIED STATISTICS-II	2.5
TYBSc	VI	RUSSTAP602	Practical based on RUSSTA603 & RUSSTA604	3

CORE COURSE

Course Code: RUSSTA101

Course Title: DESCRIPTIVE STATISTICS - I

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Distinguish between different types of scales. Compare the different types of data and describe the various methods of data collection.
CO 2	Compute Yule's coefficient of association Q and Yule's coefficient of

	Colligation Y and associate two attributes, and relate Q and Y.
CO 3	Construct Univariate and Bivariate frequency distribution of discrete, continuous variables and Cumulative frequency distribution. Draw Graphs and Diagrams: Histogram, Polygon/curve, Ogives. Heat Map, Tree map.
CO 4	Describe the need of measures of central tendency, Explain the various measures of central tendencies. Relate mean, median and mode. Justify merits and demerits of using different measures.
CO 5	Compute and comprehend the measures of dispersion. Compare Absolute and Relative measures of dispersion.
CO 6	Relate raw moments and central moments. Understand Skewness and Kurtosis of data. Identify the outliers.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA101	**Unit I**	**Types of Data and Data Condensation:** • **Global Success stories of Statistics/Analytics in various fields.** • Concept of Population and Sample. Finite, Infinite Population, Notion of SRS, SRSWOR and SRSWR • Different types of scales: Nominal, Ordinal, Interval and Ratio. • Methods of Data Collection: i) Primary data: concept of a Questionnaire and a Schedule, ii) Secondary Data • Types of data: Qualitative and Quantitative Data; Time Series Data and Cross Section Data, Discrete and Continuous Data • Univariate frequency distribution of discrete and continuous variables. Cumulative frequency distribution • Data Visualization: Graphs and Diagrams: Histogram, Polygon/curve, Ogives. Heat Map, Tree map. • Bivariate Frequency Distribution of discrete and continuous variables	15 Lectures
RUSSTA101	**Unit II**	**Measures of central tendency** • Concept of central tendency of data, Requirements of good measures of central tendency.	15 Lectures

		• Location parameters: Median, Quartiles, Deciles, and Percentiles • Mathematical averages Arithmetic mean (Simple, weighted mean, combined mean), Geometric mean, Harmonic mean, Mode, Trimmed mean. • Empirical relation between mean, median and mode. • Merits and demerits of using different measures & their applicability.	
RUSSTA101	**Unit III**	**Measures of Dispersion, Skewness & Kurtosis** • Concept of dispersion, Requirements of good measure • Absolute and Relative measures of dispersion: Range, Quartile Deviation, Inter Quartile Range, Mean absolute deviation, Standard deviation. • Variance and Combined variance, raw moments and central moments and relations between them. Their properties • Concept of Skewness and Kurtosis: Measures of Skewness: Karl Pearson's, Bowley's and Coefficient of skewness based on moments. Measure of Kurtosis. Absolute and relative measures of skewness. Box Plot: Outliers	15 Lectures

Distribution of topics for Practical

Course Code RUSSTAP101(A)	
Sr. No.	**Practical based on course**
1	Classification of Data
2	Diagrammatic representation
3	Measures of central tendency-1
4	Measures of central tendency-2
5	Measures of dispersion
6	Moments, Skewness and Kurtosis
7	Practical using Excel i) Classification of Data ii) Diagrammatic representation iii) Measures of central tendency iv) Measures of dispersion

CORE COURSE

Course Code: RUSSTA102

Course Title: STATISTICAL METHODS- I

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Differentiate between random and non-random experiments
CO 2	Compute the probabilities of events
CO 3	Understand the concept of a random variable, its probability distribution of a random variable (one or two) and its properties
CO 4	Apply standard discrete probability distributions based on real life situations

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA102	Unit I	**Elementary Probability Theory** • Trial, random experiment, sample point and sample space. • Definition of an event, Operation of events, mutually exclusive and exhaustive events. • Classical (Mathematical) and Empirical definitions of Probability and their properties. • Theorems on Addition and Multiplication of probabilities • Independence of events, Pair-wise and Mutual Independence for three events, Conditional probability, Bayes' theorem and its applications	15 Lectures
RUSSTA102	Unit II	**Discrete random variable** • Random variable. Definition and properties of probability distribution and cumulative distribution function of discrete random variable. • Raw and Central moments and their relationships.	15 Lectures

		• Concepts of Skewness and Kurtosis and their uses. • Expectation of a random variable. Theorems on Expectation & Variance. • Joint probability mass function of two discrete random variables. Independence of two random variables. • Marginal and conditional distributions. Theorems on Expectation &Variance, Covariance and Coefficient of Correlation.	
RUSSTA102	**Unit III**	**Some Standard Discrete Distributions** • Degenerate (one point): Discrete Uniform, Bernoulli, Binomial, Poisson and Hypergeometric distributions derivation of their mean and variance for all the above distributions. • Recurrence relationship for probabilities of Binomial and Poisson distributions, Poisson approximation to Binomial distribution, Binomial approximation to hypergeometric distribution.	15 Lectures

Distribution of topics for Practical

Course Code RUSSTAP101(B)	
Sr. No.	**Practicals based on course**
1	Probability
2	Discrete Random Variables
3	Bivariate Probability Distributions
4	Binomial Distribution
5	Poisson Distribution
6	Hypergeometric Distribution
7	Practical using Excel i) Binomial distribution ii) Poisson distribution iii) Hypergeometric distribution

References:

1. Medhi J.: “Statistical Methods, An Introductory Text”, Second Edition, New Age International Ltd.
2. Agarwal B.L.: “Basic Statistics”, New Age International Ltd.
3. Spiegel M.R.: “Theory and Problems of Statistics”, Schaum’s Publications series. Tata McGraw-Hill.
4. Kothari C.R.: “Research Methodology”, Wiley Eastern Limited.
5. David S.: “Elementary Probability”, Cambridge University Press.
6. Hoel P.G.: “Introduction to Mathematical Statistics”, Asia Publishing House.

7. Hogg R.V. and Tannis E.P.: “Probability and Statistical Inference”. McMillan Publishing Co. Inc.
8. Pitan Jim: “Probability”, Narosa Publishing House.
9. Goon A.M., Gupta M.K., Dasgupta B.: “Fundamentals of Statistics”, Volume II: The World Press Private Limited, Calcutta.
10. Gupta S.C., Kapoor V.K.: “Fundamentals of Mathematical Statistics”, Sultan Chand &Sons
11. Gupta S.C., Kapoor V.K.: “Fundamentals of Applied Statistics”, Sultan Chand & Sons

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks
Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours duration**.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 subparts	20	Unit I
2	Any 2 out of 3 subparts	20	Unit II
3	Any 2 out of 3 subparts	20	Unit III
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks

Particulars	Marks
Journal and attendance	5
Assignments using Statistical Software	15
Total	**20**

B) External Examination: 60%- 60 Marks

Semester End Practical Examination:
Duration - These examinations shall be of **one and half hour** duration.

Particulars	Paper
Exam (There shall be **Three** COMPULSORY Questions of 10 marks each with internal choice**)**	30
Total	**30**

Overall Examination & Marks Distribution Pattern

Semester I

Course	RUSSTA101			RUSSTA102			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical	20	30	50	20	30	50	100

CORE COURSE

Course Code: RUSSTA201
Course Title: DESCRIPTIVE STATISTICS - II

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Compute the numerical measures to identify the direction and strength of linear relationship between two variables using. Also, list their properties.
CO 2	Build a simple linear regression model and interpret regression coefficients and coefficient of determination.
CO 3	Calculate and interpret various measures of associations between two attributes.
CO 4	Identify various components of time series. Apply the appropriate methods to evaluate and eliminate these components.
CO 5	Comprehend the concept and construct various index numbers.
CO 6	Use the basic mathematical operators in R for different data types. Apply different data management techniques and data visualisation.

DETAILED SYLLABUS

Course Code / Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA201	UNIT I	**Correlation and Attributes** • Karl Pearson's Product moment correlation coefficient and its properties. • Spearman's Rank correlation. (With and without ties) • Tabulation • Dichotomous classification- for two and three attributes, Verification for consistency • Association of attributes: Yule's coefficient of association Q. Yule's coefficient of Colligation Y, Relation between Q and Y (with proof). • Measures of association with the help of	15 LECTURES

		Tau A, Tau B, Tau C, Gamma and Lambda, Somer's d	
RUSSTA201	**Unit II**	**Simple linear Regression Analysis and Fitting of curves** • Concept of Simple linear regression. Principle of least squares. Fitting a straight line by method of least squares (Linear in Parameters) • Relationship between regression coefficients and correlation coefficient, cause and effect relationship, Spurious correlation. • Concept and use of coefficient of determination (R^2). • Fitting of curves reducible to linear form by transformation.	15 LECTURES
RUSSTA201	**UNIT III**	**Time Series and Index numbers** • Definition of time series. Components of time series. Models of time series. • Estimation of trend by: (i) Freehand Curve Method (ii) Method of Semi Average (iii) Method of Moving Average (iv) Method of Least Squares (Linear Trend only) • Estimation of seasonal component by (i) Method of Simple Average (ii) Ratio to Moving Average (iii) Ratio to Trend Method • Simple exponential smoothing • Stationary Time series **Index numbers:** • Index numbers as comparative tool. Stages in the construction of Price Index Numbers. • Measures of Simple and Composite Index Numbers. Laspeyre's, Paasche's, Marshal-Edgeworth's, Dobisch & Bowley's and Fisher's Index Numbers formula • Quantity Index Numbers and Value Index Numbers Time reversal test, Factor reversal test, Circular test • Fixed base Index Numbers, Chain base Index Numbers. Base shifting, splicing and deflating. • Cost of Living Index Number. Concept of Real Income.	15 LECTURES

Distribution of topics for Practical

Course Code RUSSTAP201(A)	
Sr. No.	**Practical based on course**
1	Correlation analysis
2	Tabulation
3	Measures of Association
4	Regression analysis
5	Fitting of curve
6	Time series
7	Index Numbers.
8	Practical using Excel i) Correlation analysis ii) Regression analysis iii) Fitting of curve iv) Moving Averages v) Exponential Smoothing

CORE COURSE

Course Code: RUSSTA202
Course Title: STATISTICAL METHODS - II

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Obtain a probability density function and cumulative distribution function for continuous random variable
CO 2	Apply standard continuous probability distributions to different situations
CO 3	Distinguish between point estimation and interval estimation
CO 4	Define the various terminologies of testing of hypotheses and apply large sample tests

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures

RUSSTA202	**UNIT I**	**Continuous random variable and some Standard Continuous Distributions** • Concept of Continuous random variable and properties of its probability distribution • Probability density function and cumulative distribution function. • Their graphical representation. • Expectation of a random variable and its properties. Measures of location, dispersion, skewness and kurtosis. • Raw and central moments (simple illustrations). • Uniform, Exponential distribution (location and scale parameter), memory less property of exponential distribution, Derivations of mean, median, variance,	15 Lectures
RUSSTA202	**UNIT II**	**Normal Distribution and Sampling Distribution** • Normal distribution • Properties of Normal distribution/curve (without proof). Use of normal tables. • Normal approximation to Binomial and Poisson distribution (statement only) • Sample from a distribution: Concept of a statistic, estimate and its sampling distribution. Parameter, its estimator and bias, unbiasedness, standard error of an estimator. • Concept of Central Limit theorem (statement only) • Sampling distribution of sample means and sample proportion difference between two population means and two proportions. • Standard errors of sample mean and sample proportion.	15 Lectures
RUSSTA202	**UNIT III**	**Basics of Theory of Estimation and Testing of hypothesis** • Point and Interval estimate of single mean, single proportion from sample of large size. • Statistical tests: Concept of hypothesis, Null and Alternative Hypothesis, Types of Errors, Critical region, Level of significance, Power • Large sample tests For testing specified value of population mean For testing specified value in difference of two means For testing specified value of population proportion For testing specified value of difference of population proportion Concept of p-value	15 Lectures

Distribution of topics for Practical

Course Code RUSSTAP201(B)	
Sr. No.	**Practical based on course**
1	Continuous Random Variables
2	Uniform and Exponential Distributions
3	Normal Distribution
4	Sampling Distribution
5	Testing of Hypothesis
6	Large sample Tests
7	Practical using Excel (i) Binomial and Poisson (ii) Uniform and Exponential (iii) Normal Distribution (iv) Sampling Distribution (v) Testing of Hypotheses (vi) Large Sample Tests

REFERENCES:

1. Medhi J.: “Statistical Methods, An Introductory Text”, Second Edition, New Age International Ltd.
2. Agarwal B.L.: “Basic Statistics”, New Age International Ltd.
3. Spiegel M.R.: “Theory and Problems of Statistics”, Schaum’s Publications series. Tata McGraw-Hill.
4. Kothari C.R.: “Research Methodology”, Wiley Eastern Limited.
5. David S.: “Elementary Probability”, Cambridge University Press.
6. Hoel P.G.: “Introduction to Mathematical Statistics”, Asia Publishing House.
7. Hogg R.V. and Tannis E.P.:“Probability and Statistical Inference”. McMillan Publishing Co. Inc.
8. Pitan Jim: “Probability”, Narosa Publishing House.
9. Goon A.M., Gupta M.K., Dasgupta B.: “Fundamentals of Statistics”, Volume II: The World Press Private Limited, Calcutta.
10. Gupta S.C., Kapoor V.K.: “Fundamentals of Mathematical Statistics”, Sultan Chand &Sons
11. Gupta S.C., Kapoor V.K.: “Fundamentals of Applied Statistics”, Sultan Chand & Sons

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 sub-parts	20	Unit I
2	Any 2 out of 3 sub-parts	20	Unit II
3	Any 2 out of 3 sub-parts	20	Unit III
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks

Particulars	Marks
Journal and attendance	5
Projects based on primary / secondary data	15
Total	**20**

B) External Examination: 60%- 60 Marks

Semester End Practical Examination:
Duration - These examinations shall be of **one and half hour** duration.

Particulars	Paper
Exam (There shall be **Three** COMPULSORY Questions of 10 marks each with internal choice**)**	30
Total	**30**

Overall Examination & Marks Distribution Pattern

Semester II

Course	RUSSTA201			RUSSTA202			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical	20	30	50	20	30	50	100

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Syllabus for

Program: B.Sc.

Program Code: (STATISTICS) RUSSTA

(Credit Based Semester and Grading System for the academic year 2022–2023)

Course Code: RUSSTA301
Course Title: PROBABILITY DISTRIBUTIONS

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION At the end of this course students will be able to
CO 1	Understand different Standard Discrete Probability Distributions.
CO 2	Differentiate between the Standard Discrete Probability Distributions, understand their properties.
CO 3	Solve problems after identifying the underlying distribution.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA301	Unit I	**Univariate Random Variables (Discrete and Continuous):** • Moment Generating Function, Cumulant generating Function-Their important properties. Relationship between moments and cumulants and their uses. • Characteristic Function- Its properties (without proof). • Transformation of random Variable	15 Lectures
RUSSTA301	Unit II	**Standard Discrete Probability Distributions:** • Uniform, Bernoulli, Binomial, Poisson, Geometric, Negative Binomial & Hypergeometric distributions. • The following aspects of the above distributions (wherever applicable) to be discussed: • Mean, Mode and Standard deviation. Moment Generating Function, Cumulant • Generating Function, Additive property, Recurrence relation for central • Moments, Skewness and Kurtosis (without proof),	15 Lectures

		Limiting distribution.	
RUSSTA301	**Unit III**	**Bivariate Probability Distributions:** • Joint Probability mass function for Discrete random variables**,** Joint Probability density function for continuous random variables. Their properties. • Marginal and conditional Distributions. Independence of Random Variables. Conditional Expectation & Variance. • Regression Function. Coefficient of Correlation. Transformation of Random Variables and Jacobian of transformation with illustrations.	**15 Lectures**

Distribution of topics for Practical

Course Code RUSSTAP301(A)	
Sr. No.	**Practical based on course**
1	Moment Generating Function, Moments.
2	Cumulant generating Function, Cumulants, Characteristic function.
3	Standard Discrete Distributions
4	Fitting Standard Discrete Distributions.
5	Bivariate Probability Distributions, Marginal & Conditional distributions, Conditional Mean, Conditional Variance, Correlation
6	Transformation of discrete & continuous random variables.

REFERENCES:

1. A. M. Mood, F.A. Graybill, D. C. Boyes, Third Edition; McGraw-Hill Book Company. Introduction to the theory of statistics
2. R.V. Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers: Introduction to Mathematical Statistics
3. R.V. Hogg, E. A. Tannis, Third Edition; Collier McMillan Publishers: Probability and Statistical Inference

4. I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.: John E. Freund's Mathematical Statistics
5. P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.: Introduction to Mathematical Statistics
6. S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.: Fundamentals of Mathematical Statistics
7. J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.: Mathematical Statistics
8. J. Medhi; Second edition; Wiley Eastern Ltd.: Statistical Methods: An Introductory Text
9. A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; The World Press Pvt. Ltd.: An Outline of Statistical Theory Vol. 1

Course Code: RUSSTA302

Course Title: THEORY OF SAMPLING

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the need of sampling and define the principal concepts in sampling
CO 2	Formulate and calculate estimates of population parameters for Simple Random Sampling, Stratified Sampling and Systematic sampling
CO 3	Contrast types of probability sampling
CO 4	Utilize auxiliary information in survey by means of Ratio and Regression method of estimation

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures

RUSSTA302	**Unit I**	**Concepts:** • Population, Population unit, Sample, Sample unit, Parameter, Statistic, Estimator, Bias, Unbiasedness, Mean square error & Standard error. • Census survey, Sample Survey. Steps in conducting a sample survey. Concepts of Sampling and Non-sampling errors. • Concepts and methods of Probability and Non-Probability sampling. **Simple Random Sampling (SRS):** • Description of Simple Random Sampling with & without replacement. • Lottery method & use of Random numbers to select Simple random sample. • Estimation of population mean & total. Expectation & Variance of the estimators, Unbiased estimator of variance of these estimators. • Estimation of population proportion. Expectation & Variance of the estimators, • Unbiased estimator of variance of these estimators. • Estimation of Sample size based on a desired accuracy in case of SRS for variables & attributes.	15 Lectures
RUSSTA302	**Unit II**	**Stratified Sampling:** • Need for Stratification of population with suitable examples. Description of Stratified Random Sample. • Advantages of stratified random Sampling. **Stratified Random Sampling:** • Estimation of population mean & total in case of Stratified Random Sampling (WOR within each stratum). Expectation & Variance of the unbiased estimators, Unbiased estimators of variances of these estimators. • Equal Allocation, Proportional allocation, Optimum allocation with and without varying costs. • Comparison of Simple Random Sampling, Stratified Random Sampling using • Proportional allocation & Neyman allocation	15 Lectures
RUSSTA302	**Unit III**	**Ratio & Regression Estimation assuming SRSWOR:** • Ratio Estimators for population Ratio, Mean &	15 Lectures

		Total. Expectation & MSE of the Estimators. Estimators of MSE. Uses of Ratio Estimator. • Regression Estimators for population Mean & Total. Expectation & Variance of the Estimators assuming known value of regression coefficient 'b'. • Estimation of 'b'. Resulting variance of the estimators. Uses of regression • Estimator. Comparison of Ratio, Regression & mean per Unit estimators. **Systematic sampling**: • Estimator of Population Mean and its Variance. Comparison of Systematic Sampling with Simple Random sampling • Introduction to Cluster sampling & Two Stage sampling with suitable illustrations.	

Distribution of topics for Practical

Course Code RUSSTAP301(B)	
Sr. No.	**Practical based on course**
1	Designing of Questionnaire.
2	Simple Random Sampling for Variables.
3	Simple Random Sampling for Attributes.
4	Estimation of Sample Size in Simple Random Sampling.
5	Stratified Random Sampling.
6	Ratio Estimation- Regression Estimation.
7	Systematic Sampling

REFERENCES:

1. W.G. Cochran; 3rd Edition; Wiley (1978): Sampling Techniques
2. M. N. Murthy; Statistical Publishing Society. (1967): Sampling Theory and methods
3. Des Raj; McGraw Hill Series in Probability and Statistics. (1968): Sampling Theory

4. P.V. Sukhatme and B.V. Sukhatme; 3rd Edition; Iowa State University Press (1984): Sampling Theory of Surveys with Applications
5. S. C. Gupta and V.K. Kapoor; 3rd Edition; Sultan Chand and Sons (2001): Fundamentals of Applied Statistics
6. Daroga Singh, F.S.Chaudhary, Wiley Eastern Ltd. (1986): Theory and Analysis of Sample Survey Designs:
7. S. Sampath, Second Edition (2005), Narosa: Sampling Theory and Methods
8. Parimal Mukhopadhyay, (1998), Prentice Hall Of India Pvt. Ltd.: Theory and Methods of Survey Sampling

Course Code: RUSSTA303

Course Title: OPERATIONS RESEARCH

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Formulate and solve a linear programming problem graphically and using simplex method.
CO 2	Obtain dual of a given problem and solve the primal from the optimum solution of a primal.
CO 3	Solve a transportation problem and its variants using various methods and optimise it.
CO 4	Solve an assignment problem and its variants using Hungarian methods.
CO 5	Process sequencing problems using Johnson's Method

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA303	**Unit I**	**Linear Programming Problem (L.P.P.):** • Mathematical Formulation: Maximization &	**15 Lectures**

		Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. • Graphical Solution for problems with two variables. Simplex method of solving problems with two or more variables. Big M method. • Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Economic interpretation of Dual.	
RUSSTA303	**Unit II**	**Transportation Problem:** • Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. • Variants in Transportation Problem: Unbalanced, Maximization type, Restricted allocations.	**15 Lectures**
RUSSTA303	**Unit III**	**Assignment Problem:** • Concept. Mathematical Formulation • Solution by: Complete Enumeration Method and Hungarian method. • Variants in Assignment Problem: Unbalanced, Maximization type. • Airline Operating Problem • Travelling Salesman Problem **Sequencing:** • Processing n Jobs through 2 and 3 Machines, 2 Jobs through m Machines and n jobs through m machines	**15 Lectures**

Distribution of topics for Practical

Course Code RUSSTAP301(C)	
Sr. No.	**Practical based on course**
1	Formulation and Graphical Solution of L.P.P.

2	Simplex Method.
3	Duality.
4	Transportation.
5	Assignment.
6	Sequencing.
7	Problems solving using TORA / EXCEL Solver.

REFERENCES:

1. Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons: Operations Research
2. Richard Broson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.: Schaum Series book in O.R.
3. Methods and Problems: Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons: Operations Research
4. J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.: Mathematical Models in Operations Research
5. Harvey M. Wagner, 2nd Edition, Prentice Hall of India Ltd.: Principles of Operations Research with Applications to Management Decisions
6. S.D.Sharma.11th edition, Kedar Nath Ram Nath & Company.: Operations Research
7. H. A.Taha.6th edition, Prentice Hall of India.: Operations Research
8. J.K.Sharma, (2001), MacMillan India Ltd.: Quantitative Techniques For Managerial Decisions

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 sub-parts	20	Unit I
2	Any 2 out of 3 sub-parts	20	Unit II
3	Any 2 out of 3 sub-parts	20	Unit III
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks

Particulars	Marks
Journal and attendance	5
Assignments using Statistical Software	15
Total	**20**

B) External Examination: 60%- 60 Marks

Semester End Practical Examination:
Duration - These examinations shall be of **one and half hour** duration.

Particulars	Paper
Exam (There shall be **Three** COMPULSORY Questions of 10 marks each with internal choice**)**	30
Total	**30**

Overall Examination & Marks Distribution Pattern

Semester III

Course	RUSSTA301	RUSSTA302	RUSSTA303	Grand Total

	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	300
Practicals	20	30	50	20	30	50	20	30	50	150

Course Code: RUSSTA401

Course Title: PROBABILITY AND SAMPLING DISTRIBUTIONS

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand different Standard Continuous Probability Distributions.
CO 2	Differentiate between the Standard Continuous Probability Distributions, understand their properties and solve problems based on these distributions.
CO 3	Apply Standard Continuous Probability Distributions in real life examples.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA401	**Unit I**	**Standard Continuous Probability Distributions:** • Rectangular, Triangular, Exponential, Gamma (with Single & Double parameter), Beta (Type I & Type II). • The following aspects of the above distributions (wherever applicable) to be discussed • Mean, Median, Mode & Standard deviation. Moment Generating Function, Additive property, Cumulant Generating Function. Skewness and Kurtosis (without proof). Interrelation between the distributions. **Normal Distribution:** • Mean, Median, Mode, Standard deviation, Moment Generating function, Cumulant Generating function, Moments & Cumulants (up to fourth order). Recurrence relation for central moments, skewness & kurtosis, Mean absolute deviation. Distribution of linear function of	**15 Lectures**

		independent Normal variables. Fitting of Normal Distribution. • Central Limit theorem for i.i.d. random variables. • Log Normal Distribution: Derivation of mean & variance.	
RUSSTA401	**Unit II**	**Chi-Square Distribution:** • Concept of degrees of freedom. Mean, Median, Mode & Standard deviation. Moment generating function, Cumulant generating function. Additive property, Distribution of the sum of squares of independent Standard Normal variables. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution (without proof). • **Applications of Chi-Square:** Test of significance for specified value of variance of a Normal population. Test for goodness of fit & Test for independence of attributes (derivation of test statistics is not expected).	**15 Lectures**
RUSSTA401	**Unit III**	**t-distribution:** • Mean, Median, Mode & Standard deviation. Derivation of t distribution using Fisher's t. Student's t. Asymptotic properties. • **Applications of t:** Confidence interval for: Mean of Normal population, difference between means of two independent Normal populations having the same variance. Test of significance of: mean of a Normal population, difference in means of two Normal populations (based on: (i) independent samples with equal variances. (Effect Size, Cohen's d) (ii) dependent samples). • **F-distribution:** Mean, Mode & Standard deviation. Distribution of: reciprocal of an F variate, Ratio of two independent Chi-squares divided by their respective degrees of freedom. Interrelationship of F with: t-distribution, Chi-square distribution & Normal distribution. • **Applications of F:** Test for equality of variances of two independent Normal populations.	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP401(A)	
Sr. No.	**Practical based on course**

1	Standard Continuous distributions.
2	Normal Distribution
3	Central Limit Theorem
4	Chi Square distribution
5	t distribution
6	F distribution
7	Practical using Excel

REFERENCES:

1. A M Mood, F.A. Graybill, D C Boyes; Third Edition; McGraw-Hill Book Company.: Introduction to the theory of statistics
2. R.V.Hogg, A.T. Craig; Fourth Edition; Collier McMillan Publishers.: Introduction to Mathematical Statistics
3. R.V.Hogg, E. A.Tannis, Third Edition; Collier McMillan Publishers.: Probability and Statistical Inference
4. I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.: John E. Freund's Mathematical Statistics
5. P.G. Hoel; Fourth Edition; John Wiley & Sons Inc.: Introduction to Mathematical Statistics
6. S.C. Gupta, V.K. Kapoor; Eighth Edition; Sultan Chand & Sons.: Fundamentals of Mathematical Statistics
7. J.N. Kapur, H.C. Saxena; Fifteenth Edition; S. Chand & Company Ltd.: Mathematical Statistics
8. J. Medhi; Second edition; Wiley Eastern Ltd.: Statistical Methods- An Introductory Text
9. A.M. Goon, M.K. Gupta, B. DasGupta; Third Edition; The World Press Pvt. Ltd.: An Outline of Statistical Theory Vol. 1

Course Code: RUSSTA402

Course Title: ANALYSIS OF VARIANCE & DESIGNS OF EXPERIMENTS

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Demonstrate analysis of one-way and two-way classification
CO 2	Explain the different components of ANOVA Table
CO 3	Define fundamental concepts in Designs of Experiment, describe the principles of designs of experiment and list the different types of experimental designs
CO 4	Analyse CRD, RBD and LSD using ANOVA
CO 5	Construct factorial experiments, analyse them and understand the concept of confounding

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA402	Unit I	**Analysis of Variance:** • Introduction, Uses, Cochran's Theorem (Statement only). • One-way classification with equal & unequal observations per class, • Two-way classification with one observation per cell. • For both the cases: Mathematical Model, Assumptions, Expectation of various sums of squares, F- test, Analysis of variance table. Least square estimators of the parameters, Expectation and Variance of the estimators, Estimation of linear contrasts, Standard Error and Confidence limits Testing for significance of elementary linear contrasts.	15 Lectures
RUSSTA402	Unit II	**Design Of Experiments:** • Concepts of Experiments, Experimental unit, Treatment, Yield, Block, Replicate, Experimental Error, Precision. • Principles of Design of Experiments: Replication, Randomization & Local Control.	15 Lectures

		• Efficiency of design D_1 with respect to design D_2. • Choice of size, shape of plots & blocks in agricultural & non-agricultural experiments. **Completely Randomized Design (CRD) & Randomized Block Design (RBD):** • Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. • Least square estimators of the parameters, Variance of the estimators, Estimation of linear contrasts, Standard Error and Confidence limits Testing for significance of elementary linear contrasts. Efficiency of RBD relative to CRD. • Missing plot technique for one missing observation in case of CRD, RBD	
RUSSTA402	**Unit III**	**Latin Square Design (LSD):** • Mathematical Model, Assumptions, Expectation of various sums of squares, F-test, Analysis of variance table. • Least square estimators of the parameters, Variance of the estimators, Estimation of treatment contrasts, Standard error and Confidence limits for elementary treatment contrasts. • Efficiency of the design relative to RBD, CRD. • Missing plot technique for one missing observation in case of LSD. **Factorial Experiments:** Definition, Purpose & Advantages. 2^2, 2^3 Experiments. • Calculation of Main & interaction Effects. Yates' method. Analysis of 2^2 & 2^3 factorial Experiments. Concept of Confounding. **(partial and total)**	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP401(B)	
Sr. No.	**Practical based on course**

1	Analysis of Variance- One Way
2	Analysis of Variance- Two Way
3	Completely Randomized Design
4	Randomized Block Design
5	Latin Square Design.
6	Missing Observations in CRD, RBD & LSD
7	Factorial Experiments
8	Practical using Excel

REFERENCES:

1. W.G. Cochran and G.M.Cox; Second Edition;John Wiley and Sons.: Experimental Designs
2. Oscar Kempthorne, John Wiley and Sons.: The Design and Analysis of Experiments
3. Douglas C Montgomery; 6th Edition;John Wiley & Sons.: Design and Analysis of Experiments
4. M.N.Das and N.C.Giri, 2nd Edition; New Age International (P) Limited; 1986: Design and Analysis of Experiments
5. Walter T Federer; Oxford & IBH Publishing Co. Pvt. Ltd.: Experimental Design, Theory and Application
6. S.C.Gupta and V.K.Kapoor; 3rd Edition; Sultan Chand and Sons (2001): Fundamentals of Applied Statistics
7. B.J. Winer, McGraw Hill Book Company.: Statistical Principles in Experimental Design

Course Code: RUSSTA403

Course Title: PROJECT MANAGEMENT AND INDUSTRIAL STATISTICS

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Draw project networks for probabilistic and deterministic time estimates to obtain critical path.
CO 2	Crash activities to optimise the project cost and update networks from time to time.
CO 3	Construct various control charts for variables and attributes to obtain standard values for future use.
CO 4	Design a single sampling plan and obtain its various characteristics and understand the concept of Double Sampling Plan

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA403	Unit I	**CPM and PERT:** • Objective and Outline of the techniques. Diagrammatic representation of activities in a project: Gantt Chart and Network Diagram. • Slack time and Float times. Determination of Critical path. Probability consideration in project scheduling. • Project cost analysis. • Updating.	15 Lectures
RUSSTA403	Unit II	**Statistical Quality Control:** • Principles of control. Process quality control of variables. *X* bar and R, X bar and Sigma Chart and their uses. Problems involving setting up standards for future use. Introduction to Six sigma limits. • Concept of Natural Tolerance Limits, Specification Limits and Detection of shift • Principles of control. Process quality control of attributes p, c, np charts and their uses. p-chart and c-chart with variable sample size. Problems involving setting up standards for future use • Acceptance sampling plan • Single Sampling Plans (without curtailment).	15 Lectures

		• OC function and OC curves. AQL, LTPD, ASN, ATI, AOQ, Consumer's risk, Producer's risk. • Double Sampling Plan (Concept only)	
RUSSTA403	**Unit III**	**Game Theory and Decision Theory:** • **GAME THEORY:** Definitions of Two-person Zero Sum Game, Saddle Point, Value of the Game, Pure and Mixed strategy. Optimal solution of two-person zero sum games. Dominance property, Derivation of formulae for (2x2) game. Graphical solution of (2xn) and (mx2) games. • **DECISION THEORY** Decision making under uncertainty: Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwicz α criterion, Minimax Regret criterion. Decision making under risk: Expected Monetary Value criterion, Expected Opportunity Loss criterion, EPPI, EVPI. Decision tree analysis.	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP401(C)	
Sr. No.	**Practical based on course**
1	PERT
2	CPM
3	Project cost analysis
4	Updating
5	Control Charts for attributes and Control Charts for variables
6	Acceptance Sampling Plans.
7	Game theory
8	Decision theory.
9	Practical using EXCEL and TORA software

REFERENCES:

1. E.L. Grant. (2nd edition) McGraw Hill, 1988.: Statistical Quality Control

2. Duncan. (3rd edition) D. Taraporewala sons & company.: Quality Control and Industrial Statistics
3. Bertrand L. Hansen, (1973), Prentice Hall of India Pvt. Ltd.: Quality Control: Theory and Applications
4. Douglas Montgomery, Arizona State University. John Wiley & Sons, Inc. (6th Edition): Statistical Quality Control
5. Gupta S.C., Kapoor V.K., Fundamentals of Applied Statistics, Sultan Chand &Sons
6. Srinath. 2nd edition, East-west press Pvt. Ltd.: PERT and CPM, Principles and Applications
7. Kantiswaroop and Manmohan Gupta. 4th Edition; S Chand & Sons.: Operations Research
8. Richard Broson. 2nd edition Tata Mcgraw Hill Publishing Company Ltd.: Schaum Series book in O.R.
9. Maurice Sasieni, Arthur Yaspan and Lawrence Friedman, (1959), John Wiley & Sons.: Operations Research: Methods and Problems
10. J K Sharma, (1989), Tata McGraw Hill Publishing Company Ltd.: Mathematical Models in Operations Research
11. S.D.Sharma.11th edition, Kedar Nath Ram Nath & Company.: Operations Research
12. H. A. Taha, 6th edition, Prentice Hall of India.: Operations Research
13. J.K.Sharma, (2001), MacMillan India Ltd.: Quantitative Techniques for Managerial Decisions

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 sub-parts	20	Unit I

2	Any 2 out of 3 sub-parts	20	Unit II
3	Any 2 out of 3 sub-parts	20	Unit III
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks

Particulars	Marks
Journal and attendance	5
Projects based on primary / secondary data	15
Total	**20**

B) External Examination: 60%- 60 Marks

Semester End Practical Examination:
Duration - These examinations shall be of **one and half hour** duration.

Particulars	Paper
Exam (There shall be **Three** COMPULSORY Questions of 10 marks each with internal choice**)**	30
Total	**30**

Overall Examination & Marks Distribution Pattern

Semester IV

Course	RUSSTA401			RUSSTA402			RUSSTA403			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	300
Practicals	20	30	50	20	30	50	20	30	50	150

Course Code: RUSSTA501

Course Title: PROBABILITYAND DISTRIBUTIONTHEORY

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:

CO 1	Apply the advanced concepts of Probability theory to various problems
CO 2	Identify Trinomial distribution and derive its joint moment generating function and multinomial distribution
CO 3	Describe bivariate normal distribution and its properties and test the significance of correlation coefficient of bivariate normal distribution
CO 4	Understand the concept of Order Statistics and its applications

Academic year 2022-23

COURSE OUTCOMES:

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA501	**Unit I**	**PROBABILITY-I:** • Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. concept of permutation and combination. • Mathematical, Statistical, Axiomatic and Subjective probability. • Sub populations and partitions. • Derivation of a) $A_{r,n}$: Number of distinguishable distributions of putting r indistinguishable balls in n cells; b) Number of distinguishable distributions of putting r indistinguishable balls in n cells such that no cell is empty. • Ordered samples and runs. • Probabilities based on a) Maxwell Boltzmann, Bose Einstein and Fermi Dirac Statistics. • Addition Theorem for N events. • Theorems on Probability of realization of: (a) At least one (b) Exactly m (c) At least m of N events A_1, A_2, A_3…A_N • Classical Occupancy Problems, Matching Problems and Guessing Problems	**15 Lectures**

RUSSTA501	**Unit II**	**JOINT MOMENT GENERATING FUNCTION, TRINOMIAL AND MULTINOMIAL DISTRIBUTION:** • Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. ➢ Concept and definition of Multivariate MGF. • **Trinomial distribution:** ➢ Definition of joint probability distribution of (X, Y). Joint moment generating function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. ➢ Marginal & Conditional distributions. Their Means & Variances. ➢ Correlation coefficient between (X, Y). Distribution of the Sum X+Y. • Extension to Multinomial distribution with parameters (n, p_1, p_2… p_{k-1}) where $p_1 + p_2 + \ldots p_{k-1} + p_k = 1$. Expression for joint MGF. Derivation of: joint probability distribution of (X_i, Xj). Conditional probability distribution of X_i given $X_j = x_j$	**15 Lectures**
RUSSTA501	**Unit III**	**BIVARIATE NORMAL DISTRIBUTION** • Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μ_{rs} where r=0, 1, 2 and s=0, 1, 2. Marginal & Conditional distributions. 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. • Distribution of sample correlation coefficient when ρ = 0. Testing the significance of a correlation coefficient. Fisher's z – transformation. Tests for i) H_0: $\rho = \rho_0$ ii) H_0: $\rho_1 = \rho_2$ Confidence interval for ρ.	**15 Lectures**
RUSSTA501	**Unit IV**	**ORDER STATISTICS** • Definition of Order Statistics based on a random sample. • Derivation of:	**15 Lectures**

		(a) Cumulative distribution function of r^{th} order statistic. (b) Probability density functions of the r^{th} order statistic. (c) Joint Probability density function of the r^{th} and the s^{th} order statistic (r<s) (d) Joint Probability density function of all n ordered statistics. • Probability density function of Median (in the case of odd sample sizes) and Range for Uniform and Exponential distributions.	

Distribution of topics for Practicals

Course Code: RUSSTAP501(A)	
Sr. No.	**Practicals based on course**
1	Probability-1
2	Probability -2
3	Multinomial Distribution
4	Bivariate Normal Distribution
5	Test for Significance of Correlation Coefficient
6	Order Statistics -1
7	Order Statistics -2

REFERENCES

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R V. & Craig Allen T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt. Ltd.
3. Mood A. M., Graybill F. A., Boes D.C.: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.

4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company.
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Biswas S.: Topics in Statistical Methodology, First edition, Wiley Eastern Ltd.
7. Kapur J. N. & Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company.
8. Chandra T. K. & Chatterjee D.: A First Course in Probability, Second Edition, Narosa Publishing House.
9. Sheldon M. Ross: Introduction to Probability Models

Course Code: RUSSTA502

Course Title: THEORY OF ESTIMATION

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the concept of estimation and various properties of a good estimator
CO 2	Apply Cramer Rao inequality to find Minimum Variance Unbiased Estimator
CO 3	Study the various techniques of Estimation
CO 4	Obtain the estimator of a parameter using Bayes' approach
CO 5	Derive Confidence Interval for different parameters
CO 6	Analyse the full rank linear model $Y= X \beta + e$, $e \sim N(0,\sigma^2)$

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA502	**Unit I**	**POINT ESTIMATION AND PROPERTIES OF ESTIMATOR- I:** • Notion of a parameter and parameter space.	**15 Lectures**

		Problem of Estimation, • Definitions of Statistic, Estimator and Estimate. • Properties of a good estimator: • Unbiasedness: Definition of an unbiased estimator, biased estimator, positive and negative bias, illustrations and examples (these should include unbiased and biased estimators for the same parameters). Proofs of the following results regarding unbiased estimators. (i) Two distinct unbiased estimators of φ(θ) give rise to infinitely many unbiased estimators. (ii) If T is an unbiased estimator of θ, then φ(T) is unbiased estimator of φ(θ) provided φ(.) is a linear function. • Consistency: Consistency: Definition, Proof of the following theorem: An estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity. • Sufficiency: Concept and definition of Sufficiency, Neymann Factorization Theorem (without proof). Exponential family of probability distributions and Sufficient statistic. • Relative efficiency of an estimator. Illustrative examples. • Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE. Fisher information function, Statement and proof of Cramer-Rao inequality, Cramer–Rao Lower Bound (CRLB), Definition of Minimum Variance Bound Unbiased Estimator (MVBUE) of $\phi(\theta)$. Definition of Efficient estimator using CRLB.	
RUSSTA502	**Unit II**	**PROPERTIES OF ESTIMATOR- II** • Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE. Fisher information function**,** Statement and proof of Cramer-Rao inequality, Cramer–Rao Lower Bound (CRLB), • Definition of minimum variance bound unbiased estimator (MVBUE) of $\phi(\theta)$. Definition of Efficient estimator using CRLB. • Method of Maximum Likelihood Estimation (M.L.E.), Definition of likelihood as a function of unknown parameter, for a random sample from i) discrete distribution ii) continuous distribution. Distinction between likelihood function and joint	**15 Lectures**

		p.d.f. / p.m.f. • Derivation of Maximum Likelihood Estimator (M.L.E.) for parameters of standard distributions (case of one and two unknown parameters). Properties of M.L.E(without proof) • Method of Moments, Derivation of moment estimators for standard distributions (case of one and two unknown parameters). Illustrations of situations where M.L.E. and Moment Estimators are distinct and their comparison using Mean Square Error. • Method of Minimum Chi-square and Modified Minimum Chi-square.	
RUSSTA502	**Unit III**	**BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL** • **Bayesian Estimation**: Prior distribution, Posterior distribution, Loss function, Risk function, Bayes' solution under Squared Error Loss Function (SELF) and Absolute Error Loss function. • **Interval Estimation**: Concept of Confidence Interval and Confidence Limits. Definition of pivotal quantity and its use in obtaining confidence limits. Derivation of 100(1-α) % equal tailed confidence interval for the parameters μ, $\mu_1 - \mu_2$ (Population variance(s) known / unknown), σ^2, σ_1^2/σ_2^2 (Normal distribution). Confidence Intervals based on asymptotic property of M.L.E. Confidence interval for the parameters of Binomial, Poisson and Exponential distribution. Equidistant confidence interval for θ based on the random sample from Uniform distribution $(0,\theta)$ by using distribution of M.L.E.	**15 Lectures**
RUSSTA502	**Unit IV**	**LINEAR MODELS** Linear Model $Y_{nX1} = X_{nXp}\beta_{pX1} + e_{nX1}$ where e follows $N(0, \sigma^2 I)$. Maximum Likelihood and Least square Estimators of β, and σ^2. Properties of the estimators. Confidence Intervals for β and σ^2. Testing Significance of the β. Best Linear Unbiased Estimator (BLUE). Gauss -Markoff Theorem for Full rank Model. Properties of the Estimator, Estimation of Linear function of parameters $l'\beta$. Its mean and variance. Confidence Interval and Testing of significance of $l'\beta$	**15 Lectures**

Distribution of topics for Practicals

Course Code: RUSSTAP501(B)	
Sr. No.	**Practicals based on course**
1	MVUE and MVBUE
2	Method of Estimation -1
3	Method of Estimation -2
4	Bayes' Estimation
5	Confidence Interval
6	Linear Models
7	Use of R software

REFERENCES:

1. Hogg R.V., Craig A.T.: Introduction to Mathematical Statistics, Fourth Edition; Collier McMillan Publishers.
2. Hogg R.V., Tannis E. A.: Probability and Statistical Inference, Third Edition; Collier McMillan Publishers.
3. Rohatgi, V. K, Ehsanes Saleh A.K. Md.: An introduction to Probability Theory and Mathematical Statistics, Second Edition, Wiley series in Probability and Statistics.
4. John E. Freund's Mathematical Statistics: I. Miller, M. Miller; Sixth Edition; Pearson Education Inc.
5. Hoe lP.G.: Introduction to Mathematical Statistics; Fourth Edition; John Wiley & Sons Inc.
6. Gupta S.C., Kapoor V.K.: Fundamentals of Mathematical Statistics; Eighth Edition; Sultan Chand & Sons.
7. Kapur J.N., Saxena H.C.: Mathematical Statistics; Fifteenth Edition; S. Chand & Company Ltd.
8. Arora Sanjay and BansiLal : New Mathematical Statistics, Satya Prakashan, New Market, New Delhi,5 (1989)
9. Pawagi V.R. & Ranade Saroj A.: Statistical Methods Using R Software; Nirali Publications.

Course Code: RUSSTA503

Course Title: BIOSTATISTICS

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand applications of Statistics in Biological Sciences and epidemiology.
CO 2	Understand the terminologies of Clinical Trials and Bioequivalence studies and use of statistics in these areas.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA503	Unit I	**EPIDEMIC MODELS** • The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals, Carrier model. • Chain binomial models. Reed - Frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of 'p' and its asymptotic variance for households of sizes up to 4. General Epidemics and Host and Vector model	15 Lectures
RUSSTA503	Unit II	**BIOASSAYS** • Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. • Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit analysis. • Indirect assays. Dose-response relationship. Condition of similarity and Monotony. Linearizing transformations. Parallel line assays. Symmetrical (2, 2) and (3, 3) parallel line assays. Validity tests using orthogonal contrasts. Point Estimate and Interval Estimate of Relative potency.	15 Lectures
RUSSTA503	Unit III	**CLINICAL TRIALS: AN INTRODUCTION** • Introduction to clinical trials: The need and ethics of clinical trials. Introduction to ICH E9 guidelines. Common terminology used in clinical trials. Over view of phases (I-IV) Study Protocol, Case record/Report form,	15 Lectures

		Blinding (Single/Double) • Randomized controlled (Placebo/Active controlled), Study Designs (Parallel, Cross Over). Estimation of Sample Size. • Types of Trials: Inferiority, Superiority and Equivalence, Multicentric Trial. Inclusion/Exclusion Criteria. Statistical tools: Analysis of parallel Design using Analysis of Variance. Repeated Measures ANOVA (Concept only) • Concept of odds ratio, Relative Risk. • Introduction to Survival Analysis for estimating Median Survival Time. Kaplan Meier approach of survival Analysis.	
RUSSTA503	**Unit IV**	**BIOEQUIVALENCE** • Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmakokinetic (PK) parameters C_{max}, AUC_t, $AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}. • Estimation of PK parameters using 'time vs. concentration' profiles. • Designs in Bioequivalence: Parallel (Analysis), Two Way Crossover, Three Way Crossover, Replicated Crossover (Concept only). Advantages of Crossover design over Parallel design. • Analysis of Parallel design using logarithmic transformation (Summary statistics, ANOVA and 90% confidence interval). • Confidence Interval approach to establish bioequivalence (80/125 rule).	**15 Lectures**

Distribution of topics for Practicals

Course Code: RUSSTAP502(A)	
Sr. No.	**Practicals based on course**
1	Epidemic models

2	Direct Assays
3	Quantal Response Assays
4	Parallel line Assay
5	Clinical Trials
6	Bioequivalence

REFERENCES:

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

Course Code: RUSSTA504
Course Title: ELEMENTS OF ACTUARIAL SCIENCE
Academic year 2022-23

COURSE OUTCOMES:

COURSE	DESCRIPTION

OUTCOME	A student completing this course will be able to:
CO 1	**Understand** the functions of Mortality Table and should be able to **relate** them with the rate of mortality and calculate probabilities of living and dyeing
CO 2	Differentiate between Nominal and Effective rate of interest. Analyse and evaluate various types of annuities certain, and also calculate the present values and accumulated values
CO 3	Distinguish between the Life annuities and Temporary annuities and calculate the present values of various Life and Temporary annuities
CO 4	Understand the difference between assurance and insurance. Evaluate the single premiums and level annual premiums for various assurance schemes. Distinguish between the Net premiums and the Office premiums

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA504	**Unit I**	**MORTALITY TABLES:** • Various mortality functions. Probabilities of living and dying. • The force of mortality. Estimation of μ_x from the mortality table. • Central Mortality Rate. Laws of mortality: Gompertz's and Makeham's first law. Select, Ultimate and Aggregate mortality tables. Stationary population. Expectation of life and Average life at death.	**15 Lectures**
RUSSTA504	**Unit II**	**COMPOUND INTEREST AND ANNUITIES CERTAIN:** • Accumulated value and present value, nominal and effective rates of interest. • Varying rates of interest. Equation of value. Equated time of payment. • Present and accumulated values of annuity certain (immediate and due) with and without deferment period. • Present value for perpetuity (immediate and due) with and without deferment Period. • Present and accumulated values of (i) increasing annuity (ii) increasing annuity when	**15 Lectures**

		successive instalments form (i) arithmetic progression (ii) Geometric progression (iii) annuity with Frequency different from that with which interest is convertible. Redemption of loan.	
RUSSTA504	**Unit III**	**LIFE ANNUITIES:** • Present value in terms of commutation functions of Life annuities and Temporary life annuities (immediate and due) with and without deferment period. • Present values of Variable, increasing life annuities and increasing Temporary life annuities (immediate and due).	**15 Lectures**
RUSSTA504	**Unit IV**	**ASSURANCE BENEFITS:** • Present value of Assurance benefits in terms of commutation functions of: (i) pure endowment assurance (ii) temporary assurance (iii) endowment assurance (iv) whole life assurance (v) special endowment assurance (vi) deferred temporary assurance (vii) Double Endowment • Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. • Office premiums.	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP502(B)	
Sr. No.	**Practical based on course**
1	Mortality tables 1
2	Mortality tables 2
3	Annuities 1
4	Annuities 2
5	Life annuities
6	Assurance benefits

REFERENCES:

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

4. Ajaykumar Srivastava and Gorakhnath Agarwal: Mathematical Basis of Life Assurance

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 sub-parts	16	Unit I
2	Any 2 out of 3 sub-parts	16	Unit II
3	Any 2 out of 3 sub-parts	14	Unit III
4	Any 2 out of 3 sub-parts	14	Unit IV
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks (Per Paper)

Particulars	Marks
Journal and attendance	5
Assignments using Statistical Software	15

Total	20

B) External Examination: 60%- 60 Marks

Semester End Practical Examination:
Duration - These examinations shall be of **THREE HOURS** duration.

Particulars	Paper
Exam (RUSSTAP501(A) & RUSSTAP501(B))	60 (3 hours)
Exam (RUSSTAP502(A) & RUSSTAP502(B))	60 (3 hours)
Total	**120**

(Every paper will consist of two parts A and B. Every **part** will consist of two questions of 30 marks each. Learners to attempt one question from each part.**)**

Overall Examination & Marks Distribution Pattern

Semester V

Course	RUSSTA501			RUSSTA502			RUSSTA503			RUSSTA504			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	20	30	50	20	30	50	20	30	50	20	30	50	200

Course Code: RUSSTA601

Course Title: DISTRIBUTION THEORY AND STOCHASTIC PROCESSES

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Use the concept of generating function for defining probability generating function and analyse its properties.
CO 2	Understand various stochastic processes and derive its parameters.
CO 3	Describe and classify various basic queueing models and derive its measures.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA601	Unit I	**GENERATING FUNCTIONS** • Definitions of generating function and probability generating function. Expression for mean and variance in terms of generating functions. • Definition of a convolution of two or more sequences. Generating function of a convolution. • Generating functions of the standard discrete distributions. Relation between: i) Bernoulli and Binomial distributions ii) Geometric and Negative Binomial distributions in terms of convolutions.	15 Lectures
RUSSTA601	Unit II	**STOCHASTIC PROCESSES** • Definition of stochastic process. Postulates and difference differential equations for : (i) Pure birth process (ii) Poisson process with initially 'a' members, for a =0 and a >0 (iii) Yule Furry process (iv) Pure death process (v) Death process with $\mu_n=\mu$ (vi) Death process with $\mu_n=n\mu$ (vii) Birth and death process (viii) Linear growth model. • Derivation of P_n (t), mean and variance where ever applicable.	15 Lectures
RUSSTA601	Unit III	**QUEUING THEORY –I** • Basic elements of the Queuing model. • Roles of the Poisson and Exponential distributions.	15 Lectures

		• Assuming the difference differential equations for birth and death process, derivation of Steady state probabilities for birth and death process. Steady state probabilities and various average characteristics for the following models: (i) (M/M/1) : (GD/∞/∞), Waiting time distributions of (M/M/1)(FCFS/∞/∞) (ii) (M/M/1) : (GD/ N/∞)	
RUSSTA601	**Unit IV**	**QUEUING THEORY –II** Other queuing models i) (M/M/c) : (GD/ ∞/ ∞), ii) (M/M/c):(GD/ N /∞), iii) (M/M/∞) : (GD/ ∞ /∞) (iv) Machine Serving model (M/M/C): (GD/ k /k) **Erlangian Model:**	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP601(A)	
Sr. No.	**Practical based on course**
1	Generating Function
2	Stochastic Processes
3	Queuing Theory -1
4	Queuing Theory -2
5	Queuing Theory -3

REFERENCES:

1. Feller W: An introduction to probability theory and it's applications, Volume: 1, Third edition, Wiley Eastern Limited.
2. Hogg R. V. & CraigA.T.: Introduction to Mathematical Statistics, Fifth edition, Pearson Education (Singapore) Pvt Ltd.

3. Mood A M, Graybill F A, Bose D C: Introduction to the theory of statistics, Third edition, Mcgraw- Hill Series.
4. Hogg R. V. and Tanis E.A.: Probability and Statistical Inference, Fourth edition, McMillan Publishing Company
5. Gupta S C & Kapoor V K: Fundamentals of Mathematical statistics, Eleventh edition, Sultan Chand & Sons.
6. Taha H.A.: Operations Research: An introduction, Eighth edition, Prentice Hall of India Pvt. Ltd.
7. Medhi J.: Stochastic Processes, Second edition, Wiley Eastern Ltd.
8. Biswas S.: Topics in Statistical Methodology (1992), First edition, Wiley Eastern Ltd.
9. Kapur J. N., Saxena H. C.: Mathematical Statistics, Fifteenth edition, S. Chand and Company

Course Code: RUSSTA602

Course Title: TESTING OF HYPOTHESES

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Define various terms in testing of hypotheses.
CO 2	Identify the Most Powerful Test using Neyman-Pearson Lemma and obtain a Uniformly Most Powerful Test
CO 3	Understand the concept of Likelihood Ratio Test (LRT) and construct LRT under different situations for a normal distribution
CO 4	Construct Sequential Probability Ratio Tests for Bernoulli, Binomial, Poisson, Normal, Exponential distributions
CO 5	Differentiate between parametric and non-parametric tests and apply various Non-parametric tests

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures

RUSSTA602	**Unit I**	**MOST POWERFUL TESTS** • Problem of testing of hypothesis. • Definitions and illustrations of i) Simple hypothesis ii) Composite hypothesis iii)Null Hypothesis iv) Alternative Hypothesis v)Test of hypothesis vi) Critical region vii) Type I and Type II errors viii) Level of significance ix) p-value x) size of the test xi) Power of the test xii) Power function of a test xiii) Power curve. • Definition of most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma.	**15 Lectures**
RUSSTA602	**Unit II**	**UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS** • Definition, Existence and Construction of uniformly most powerful (UMP) test. Likelihood ratio principle. • Definition of test statistic and its asymptotic distribution (statement only) • Construction of LRT for the mean of normal distribution for i) known σ^2 ii) unknown σ^2 (two sided alternatives). • LRT for variance of normal distribution for i) known μ ii) unknown μ (two sided alternatives hypotheses)	**15 Lectures**
RUSSTA602	**Unit III**	**SEQUENTIAL PROBABILITY RATIO TEST (SPRT)** • Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure. • Definition of Wald's SPRT of strength (α, β). Problems based on Bernoulli, Binomial, Poisson, Normal, Exponential distributions. Graphical /tabular procedure for carrying out the tests. • ASN and OC Function	**15 Lectures**
RUSSTA602	**Unit IV**	**NON-PARAMETRIC TESTS** • Need for non-parametric tests. • Distinction between a parametric and a non-parametric test. • Concept of a distribution free statistic. Nonparametric tests. (i) Sign test (Single and	**15 Lectures**

		Two samples) (ii) Wilcoxon's signed rank test (iii) Median test (iv) Mann–Whitney test (v) Run test. (Single and Two samples) (vi) Fisher Exact Test (vii) Kruskal Wallis ANOVA (viii) Friedman ANOVA • Assumptions, justification of the test procedure for small & large samples.	

Distribution of topics for Practical

Course Code: RUSSTAP601(B)	
Sr. No	**Practical based on course**
1	Testing of Hypothesis 1
2	Testing of Hypothesis-2
3	SPRT
4	Non-Parametric test-1
5	Non-Parametric test-2
6	Use of R software.

REFERENCES:

1. Hogg R.V. and Craig A.T: Introduction to Mathematical Statistics Fourth edition London Macmillan Co. Ltd.
2. Hogg R.V. and Tanis E.A.: Probability and Statistical Inference. Third edition Delhi Pearson Education.
3. Lehmann, E. L: Testing of Statistical Hypothesis, Wiley &sons
4. Rao, C. R.: Linear Statistical Inference,
5. Daniel W. W.: Applied Non Parametric Statistics First edition Boston-Houghton Mifflin Company.
6. Wald A.: Sequential Analysis First edition New York John Wiley & Sons
7. Biswas S.: Topics in Statistical Methodology. First edition New Delhi Wiley eastern Ltd.
8. Gupta S.C. and Kapoor V.K.: Fundamentals of Mathematical Statistics Tenth edition New Delhi S. Chand & Company Ltd.
9. Sanjay Aroraand BansiLal: New Mathematical Statistics, Satya Prakashan, New Market, New Delhi, 5(1989).

10. Pawagi V. R. and Ranade Saroj A: Statistical Methods Using R Software. Nirali Publications.

Course Code: RUSSTA603

Course Title: APPLIED STATISTICS-I

Academic year 22-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the various costs of Inventory and derive the economic order quantity and reorder period, for deterministic and probabilistic inventory models
CO 2	Obtain the optimum age of replacement of an item for different situations and distinguish between individual and group replacement policies
CO 3	Simulate random numbers and random observations for various probability distributions. Apply Monte-Carlo technique to solve problems in Inventory and Queueing Theory.
CO 4	Understand the various terminologies of Micro Economics and its applications.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA603	**Unit I**	**INVENTORY CONTROL** • Introduction to Inventory Problem • Deterministic Models: Single item static EOQ	**15 Lectures**

		models for: ➢ Constant rate of demand with instantaneous replenishment, with and without shortages. ➢ Constant rate of demand with uniform rate of replenishment, with and without shortages. ➢ Constant rate of demand with instantaneous replenishment without shortages, with one and two price breaks. • Probabilistic models: Single period with ➢ Instantaneous demand (discrete and continuous) without setup cost. ➢ Uniform demand (discrete and continuous) without set up cost.	
RUSSTA603	**Unit II**	**REPLACEMENT** • Replacement of items that deteriorate with time and value of money that remains constant and that change with time. • Replacement of items that fail completely: Individual replacement and Group replacement policies.	**15 Lectures**
RUSSTA603	**Unit III**	**SIMULATION** • Scope of simulation applications. Types of simulation. Monte Carlo Technique of Simulation and Bootstrapping. • Elements of discrete event simulation. • Generation of random numbers. Sampling from probability distribution. Inverse method. Generation of random observations from i) Uniform distribution ii) Exponential distribution iii) Gamma distribution iv) Normal distribution. • Application of Simulation techniques to real life situations.	**15 Lectures**
RUSSTA603	**Unit IV**	**Mathematical Economics:** • Behaviour of Demand and Supply, Demand functions. Cost and Revenue functions. The elasticity of a function, Elasticity of (i) Demand (ii) Cost. • Normal conditions of (i) demand (ii) cost. Features of prefect competition. • Monopoly (including effects of taxation and subsidy), Duopoly. • Production function. Euler's theorem linear homogenous production functions, Cobb-Douglas production function, CES production function.	15 Lectures

		• The elasticity of substitution.	

Distribution of topics for Practical

Course Code: RUSSTAP602(A)	
Sr. No.	**Practical based on course**
1	Inventory-1
2	Inventory-2
3	Replacement
4	Simulation
5	Mathematical Economics 1
6	Mathematical Economics 2

REFERENCES:

1. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies
2. Bannerjee B. : Operation Research Techniques for Management, First edition, Business books
3. Bronson R. : Theory and problems of Operations research, First edition, Schaum's Outline series
4. Kantiswarup, P.K. Gupta, Manmohan : Operations Research, Twelfth edition, Sultan Chand & sons
5. Sharma S. D.: Operations Research, Eighth edition, Kedarnath Ramnath & Co.
6. Taha H.A.: Operations Research An Introduction, Prentice Hall of India
7. Allen R.G.D.: Mathematical Analysis for Economics
8. Henderson J. M. and Quandt R. E.: Micro Economic Theory-A mathematical approach
9. Gupta S.C. and Kapoor V. K.: Fundamentals of Applied Statistics

Course Code: RUSSTA604

Course Title: APPLIED STATISTICS-II

Academic year 2022-23

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the concept of Predictive modelling and use techniques like regression analysis, time series for real life situations.
CO 2	Understand an important concept of Reliability and the mathematical aspects of computing reliability in different scenarios.
CO 3	Apply k-means clustering method of classification.

DETAILED SYLLABUS

Course Code/ Unit	Unit	Course/ Unit Title	Credits/ Lectures
RUSSTA604	Unit I	**LINEAR REGRESSION I** • Linear regression model with one or more explanatory variables. Assumptions of the model, Derivation of Ordinary Least Square (OLS) estimators of regression coefficients, (for one and two explanatory variables models). Properties of least square estimators (without proof). Coefficient of determination R^2 and adjusted R^2. • Procedure of testing: ➢ Overall significance of the model ➢ Significance of individual coefficients • Significance of incremental contribution of explanatory variable for two explanatory variables model. • Confidence intervals for the regression coefficients. • Multiple Linear Regression with Qualitative Independent Variable.	15 Lectures
RUSSTA604	Unit II	**LINEAR REGRESSION II** • Autocorrelation: Concept, Detection using Durbin Watson Test, Generalized Least Square (GLS) method. • Heteroscedasticity: Concept, Detection using Breusch-Pagan-Godfrey test. Weighted Least Square (WLS) estimators	15 Lectures

		• Multicollinearity: Concept, Detection using (i) R square & t ratios (ii) Variance Inflation Factor (VIF), • Remedial measures for Multicollinearity: Ridge Regression. • Concept of Statistical Outliers, Detection of Influential Observation. Cook's Distance and Influence Plot. Hold Out method for Model Validation. • Binary Logistic Regression, Concept of Multinomial and ordinal logistic • Step-wise Regression**: Concept and Use**	
RUSSTA604	**Unit III**	**RELIABILITY** • Concept of reliability, Hazard-rate. Bath tub curve. • Failure time distributions: (i) Exponential (ii) Gamma (iii) Weibull (iv) Gumbel. • Definitions of increasing (decreasing) failure rate. • System Reliability. Reliability of (i) series; (ii) parallel system of independent components having exponential life distributions. • Mean Time to Failure of a system (MTTF).	**15 Lectures**
RUSSTA604	**Unit IV**	**CLUSTER ANALYSIS AND TIME SERIES MODELS** • Cluster Analysis: Introduction to cluster analysis, difference between k-means and hierarchical methods of clustering. Applications of clustering. Use of R to carry out k-means clustering. • Time Series Models: Concept of stationary time series (graphical and DF test, Methods of converting non-stationary time series into stationary time series by differencing method and detrending method, introduction to Box-Jenkin's ARIMA model (5 steps)	**15 Lectures**

Distribution of topics for Practical

Course Code: RUSSTAP602(B)	
Sr. No.	**Practical based on course**
1	Multiple regression model -1

2	Multiple regression model- 2
3	Use of R in MLR, Binary Logistic Regression
4	Reliability
5	Cluster Analysis
6	Time Series Regression-ARMA/ ARIMA

REFERENCES:

1. Gupta S. C. &. Kapoor V. K.: Fundamentals of Applied Statistics, Fourth edition, Sultan Chand & Sons.
2. Sharma J. K.: Operations Research Theory and Application, Third edition, Macmillan India Ltd.
3. Spiegel M.R. : Theory and Problems of Statistics, Fourth edition, Schaum's Outline Series Tata McGraw Hill
4. Taha Hamdy A. : Operations Research : Eighth edition, Prentice Hall of India Pvt. Ltd
5. VoraN. D.: Quantitative Techniques in Management, Third edition, McGraw Hill Companies
6. Barlow R.E. and Prochan Frank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston
7. Mann N.R., Schafer R.E., Singapurwalla N.D.: Methods for Statistical Analysis of Reliability and Life Data, First edition, John Wiley & Sons.
8. Damodar Gujrathi, Sangetha S: Basic Econometrics, Fourth edition, McGraw-Hill Companies.
9. Greene William: Econometric Analysis, First edition, McMillan Publishing Company.
10. Johnson and Richen : Applied Multivariate Statistical Analysis .

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment- 40%- 40 Marks

Sr No	Evaluation type	Marks
1	Class Test/ Project / Assignment / Presentation	20
2	Class Test/ Project / Assignment / Presentation	20
	TOTAL	**40**

B) External Examination- 60%- 60 Marks
Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
1	Any 2 out of 3 sub-parts	16	Unit I
2	Any 2 out of 3 sub-parts	16	Unit II
3	Any 2 out of 3 sub-parts	14	Unit III
4	Any 2 out of 3 sub-parts	14	Unit IV
	TOTAL	**60**	

Practical Examination Pattern:

A) Internal Examination: 40%- 40 Marks (Per Practical Paper)

Particulars	Marks
Journal and attendance	5
Projects based on primary / secondary data	15
Total	**20**

B) External Examination: 60%- 60 Marks (Per Practical Paper)
Semester End Practical Examination:
Duration - These examinations shall be of **THREE HOURS** duration.

Particulars	Paper

Exam (RUSSTAP601(A) & RUSSTAP601(B))	60 (3 hours)
Exam (RUSSTAP602(A) & RUSSTAP602(B))	60 (3 hours)
Total	**120**

(Every paper will consist of two parts A and B. Every **part** will consist of two questions of 30 marks each. Learners to attempt one question from each part. Each question will be based on all units.**)**

Overall Examination & Marks Distribution Pattern
Semester VI

Course	RUSSTA601			RUSSTA602			RUSSTA603			RUSSTA604			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practical	20	30	50	20	30	50	20	30	50	20	30	50	200
