Resolution No.: AC/II(22-23).3.RUS11

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

RUIA COLLEGE
Explore • Experience • Excel

Syllabus for

Program: T.Y.B.Sc.

Program Code: (STATISTICS) RUSSTA

(Credit Based Semester and Grading System for academic year 2023–2024)

Ramnarain Ruia Autonomous College

GRADUATE ATTRIBUTES

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.

GA	GA Description **A student completing Bachelor's Degree in Science program will be able to:**
GA 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.
GA 2	Evaluate scientific ideas critically, analyse problems, explore options for practical demonstrations, illustrate work plans and execute them, organise data and draw inferences.
GA 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.
GA 4	Ask relevant questions, understand scientific relevance, hypothesize a scientific problem, construct and execute a project plan and analyse results.
GA 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.
GA 6	Apply scientific information with sensitivity to values of different cultural groups. Disseminate scientific knowledge effectively for upliftment of the society.
GA 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.
GA 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.

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PROGRAM OUTCOMES

PO	Description **A student completing Bachelor's Degree in Science program in the subject of Statistics will be able to:**
PO 1	Understand, condense, visualize, analyze and interpret various data types generated in various scenarios of scientific, industrial, or social problems.
PO 2	Apply Statistical tools for data analysis.
PO 3	Pursue their higher education programs leading to post-graduate and/or doctoral degrees in Statistics, Data Science, Business Analytics, Biostatistics, Econometrics, Management Studies.
PO 4	Compete globally to enter into promising careers.
PO 5	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.
PO 6	Seek employment or self-employment in different sectors like Stock trading, Pharmaceutical sector, Sports, Politics, Business, Financial services and Media Industry.

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PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
TYBSc	V	RUSSTA501	PROBABILITY AND DISTRIBUTION THEORY	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	DISTRIBUTION THEORY 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

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Course Code: RUSSTA501

Course Title: PROBABILITYAND DISTRIBUTIONTHEORY

Academic year 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the advanced concepts of Probability theory to address diverse problems.
CO 2	Use Trinomial distribution, derive its joint moment generating function, and explore multinomial distribution.
CO 3	Use bivariate normal distribution, its properties, and assess the significance of correlation coefficient of Bivariate Normal Distribution.
CO 4	Understand and apply Order Statistics to estimate population parameters.

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	15 Lectures

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		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	
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 $p_1 + p_2 +… p_{k-1} + p_k = 1$. 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.	**15 Lectures**

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		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.	
RUSSTA501	**Unit IV**	**ORDER STATISTICS** • Definition of Order Statistics based on a random sample. • Derivation of: (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.	**15 Lectures**

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

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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 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the use of Theory of estimation and the key properties of a good estimator.
CO 2	Utilize Cramer Rao inequality to determine the Minimum Variance Unbiased Estimator.
CO 3	Use different approaches like point estimation, interval estimation, and Bayes' estimation.
CO 4	Understand the full rank general linear model for analysis and its use.

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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. 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 $\varphi(\theta)$ give rise to infinitely many unbiased estimators. (ii) If T is an unbiased estimator of θ, then $\varphi(T)$ is unbiased estimator of $\varphi(\theta)$ provided $\varphi(.)$ 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.	**15 Lectures**
RUSSTA502	**Unit II**	**PROPERTIES OF ESTIMATOR- II** • Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE. Fisher information	**15 Lectures**

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		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 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**

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RUSSTA502	**Unit IV**	**LINEAR MODELS** Linear Model $Y_{nX1} = X_{nXp}\beta_{pX1} + e_{nX1}$ where e follows N(0, σ^2I). 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.

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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 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Analyse the spread and impact of epidemics using statistical methods and models.
CO 2	Identify and apply appropriate techniques for epidemiological data analysis, including disease transmission dynamics and risk factor identification.
CO 3	Differentiate between various methods used for potency estimation in bioassays and apply them effectively.
CO 4	Understand the principles of dose-response relationships in bioassays and employ statistical techniques to characterize these relationships.
CO 5	Apply statistical methodologies to design and analyze clinical trials effectively.
CO 6	Differentiate between various types of clinical trial designs and select appropriate methods for specific research objectives.
CO 7	Understand the statistical principles underlying randomization, blinding, and allocation concealment in clinical trials.
CO 8	Apply advanced statistical methods, such as survival analysis or Bayesian approaches, to analyze complex clinical trial data and derive

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	meaningful conclusions.
CO 9	Apply statistical methods to assess bioequivalence between two pharmaceutical formulations.
CO 10	Understand the regulatory guidelines and requirements for bioequivalence studies and ensure compliance with relevant standards.
CO 11	Differentiate between various statistical approaches used to evaluate bioequivalence and select appropriate methods based on study design and objectives.
CO 12	Interpret bioequivalence study results and make informed decisions regarding the similarity or differences between drug formulations.

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**	**CLINICAL TRIALS: AN INTRODUCTION**	**15**

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	III	• 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, 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.	**Lectures**
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**

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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

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Course Code: RUSSTA504
Course Title: ELEMENTS OF ACTUARIAL SCIENCE

Academic year 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the purpose of Mortality Tables and compute the likelihood of survival and death.
CO 2	Distinguish between different types of annuities, assess their worth now and in the future.
CO 3	Explain the need for various assurance plans and determine the premiums for each.

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 successive instalments form (i) arithmetic progression (ii) Geometric	15 Lectures

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		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 Practicals

Course Code: RUSSTAP502(B)	
Sr. No.	**Practicals 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

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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 two out of A B or C	16	Unit I
2	Any two out of A B or C	16	Unit II
3	Any two out of A B or C	14	Unit III
4	Any two out of A B or C	14	Unit IV
	TOTAL	**60**	

Practical Examination Pattern:

Particulars	Marks
Journal	10 x 4 = 40
Total	**40**

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

Particulars	Paper
RUSSTAP501(A) based on RUSSTA501	40 (1.5 hours)
RUSSTAP501(B) based on RUSSTA502	40 (1.5 hours)
RUSSTAP502(A) based on RUSSTA503	40 (1.5 hours)
RUSSTAP502(B) based on RUSSTA504	40 (1.5 hours)
Total	**160**

(There will be Two question with 4 parts each. Each part will be based on one unit for 10 marks. Student will attempt any one question.)

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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	10	40	50	10	40	50	10	40	50	10	40	50	200

Course Code: RUSSTA601

Course Title: DISTRIBUTION THEORY AND STOCHASTIC PROCESSES

Academic year 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand and use the concept of generating functions and probability generating functions, and analyze their properties.
CO 2	Understand and apply different stochastic processes and calculate their parameters through derivation.
CO 3	Describe and categorize various fundamental queueing models and compute their performance 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 $\mu_n=n\mu$	15 Lectures

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		(vii) Birth and death process (viii) Linear growth model. • Derivation of P_n (t), mean and variance where ever applicable.	
RUSSTA601	**Unit III**	**QUEUING THEORY –I** • Basic elements of the Queuing model. • Roles of the Poisson and Exponential distributions. • 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/∞)	**15 Lectures**
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)	**15 Lectures**

Distribution of topics for Practicals

Course Code: RUSSTAP601(A)	
Sr. No.	**Practicals 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.

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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 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Distinguish between the Most Powerful Test and Uniformly Most Powerful Test.
CO 2	Develop hypotheses testing using Likelihood Ratio Test (LRT).
CO 3	Create Sequential Probability Ratio Tests for Bernoulli, Binomial, Poisson, Normal, and Exponential distributions.
CO 4	Differentiate between parametric and non-parametric tests and apply various Non-parametric tests as appropriate.

DETAILED SYLLABUS

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

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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**

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		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 Practicals

Course Code: RUSSTAP601(B)	
Sr. No	**Practicals 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).

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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 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Calculate the economic order quantity and reorder period for both deterministic and probabilistic inventory models.
CO 2	Optimize the replacement age of an item for various scenarios and differentiate between individual and group replacement policies.
CO 3	Generate random numbers and observations following various probability distributions. Apply Monte Carlo techniques to address problems in Inventory and Queueing Theory.
CO 4	Use the properties of mathematical functions in Economics and understand their relationships.

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 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	**15 Lectures**

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		➢ 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. • The elasticity of substitution.	15 Lectures

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Distribution of topics for Practicals

Course Code: RUSSTAP602(A)	
Sr. No.	**Practicals 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

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Course Code: RUSSTA604

Course Title: APPLIED STATISTICS-II

Academic year 2023-24

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Understand the principles and assumptions underlying multiple linear regression analysis.
CO 2	Identify and evaluate the relationships between multiple independent

	variables and a dependent variable.
CO 3	Perform model diagnostics and assess the goodness of fit of multiple linear regression models.
CO 4	Understand the fundamental concepts and measures of reliability.
CO 5	Apply statistical methods to assess and analyze reliability data.
CO 6	Evaluate the reliability of systems, components, or processes using appropriate reliability models and techniques.
CO 7	Understand the principles and concepts of time series modeling.
CO 8	Apply various time series analysis techniques, such as decomposition, smoothing, and forecasting methods.
CO 9	Evaluate the stationarity of time series data and implement appropriate transformations if necessary.
CO 10	Understand the principles and concepts of cluster analysis.
CO 11	Identify appropriate clustering techniques based on data characteristics and research objectives.
CO 12	Apply clustering algorithms such as K-means

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.	**15 Lectures**

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		• Confidence intervals for the regression coefficients. • Multiple Linear Regression with Qualitative Independent Variable.	
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 • 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**	**15 Lectures**
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	**15 Lectures**

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		detrending method, introduction to Box-Jenkin's ARIMA model (5 steps)	

Distribution of topics for Practicals

Course Code: RUSSTAP602(B)	
Sr. No.	**Practicals 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.

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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 two out of A B or C	16	Unit I
2	Any two out of A B or C	16	Unit II
3	Any two out of A B or C	14	Unit III
4	Any two out of A B or C	14	Unit IV
	TOTAL	**60**	

Practical Examination Pattern:

Particulars	Marks

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Journal	10 x 4
Total	**40**

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

Particulars	**Paper**
RUSSTAP501(A) based on RUSSTA501	40 (1.5 hours)
RUSSTAP501(B) based on RUSSTA502	40 (1.5 hours)
RUSSTAP502(A) based on RUSSTA503	40 (1.5 hours)
RUSSTAP502(B) based on RUSSTA504	40 (1.5 hours)
Total	**160**

(There will be Two question with 4 parts each. Each part will be based on one unit for 10 marks. Student will attempt any one question.)

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
Practicals	10	40	50	10	40	50	10	40	50	10	40	50	200

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