Resolution No.: AB/I(17-18).3.RUS11

S. P. Mandali's

Ramnarain Ruia Autonomous College

Syllabus for : F.Y.B.Sc.

Program: B.Sc.

Course: STATISTICS (RUSSTA)

(Credit Based Semester and Grading System with effect from the academic year 2017–2018)

Preamble

B. Sc. Statistics program is of 120 credits spread over six semesters. This program is offered at the Department of Statistics, Ramnarain Ruia Autonomous College, Matunga, Mumbai.

The program develops a wide range of skills beyond knowledge of statistical topics, including mathematical, computational and non-mathematical skills.

The program emphasizes on theory and applications of statistics. It is well structured to provide the knowledge and skills in depth necessary for the employability of students in industry, other organizations, as well as in academics.

Ramnarain Ruia Autonomous College has the academic autonomy. The independent projects and presentation work is one of the important components of this program. The syllabus offers four courses in the first year (two semesters) and it covers most of the basic core concepts. The second year syllabus has four core and two of applied nature courses. The syllabus has been framed to have a good balance of theory, methods and applications of statistics. The third year offers two courses of core statistics and two courses of applied statistics in each semester. Practical courses in all three years are designed to enhance the ability of students to study the applications of the core courses and to develop the interpretation skills. The presentations on various topics develop students' public speaking and communication skills.

SEMESTER I

Course Code	UNIT	TITILE	Credits	Lectures / Week
		DESCRIPTIVE STATISTICS I		
RUSSTA101	I	Types of Data and Data Condensation	2	1
	II	Measures of central tendency		1
	III	Measures of Dispersion, Skewness & Kurtosis		1
Course Code	UNIT	TITILE	Credits	Lectures / Week
		STATISTICAL METHODS - I		
RUSSTA102	I	Elementary Probability Theory	2	1
	II	Discrete random variable		1
	III	Some Standard Discrete Distributions		1
RUSSTAP101	Practical based on courses RUSSTA101, RUSSTA102		2	6

Objective of Course

In the first year, there will be two courses in Statistics per semester. The following are the objectives of these courses:

1. To understand various data types and to learn visualization techniques.
2. To enable learners to summarize data quantitative and graphical methods.
3. To teach learners fundamentals of probability and probability distributions
4. To equip learners with requisite quantitative techniques.
5. To develop learner's presentation and communication skills.

Learning Outcomes

1. Learners will be able to visualize data using elementary graphs and diagrams and will be able to apply appropriate measures for quantitative and qualitative data.

2. Learners will be able to choose and apply an appropriate statistical analysis or modeling methods to solve problems arising in different fields.

3. Learners will be able to use statistical tools to solve problems from different fields.

4. Learners will be able to engage in interpretation of wide range of information from variety of disciplines including quantitative analysis.

SEMESTER I

Course Code	UNIT	TITLE	Credits	L / Week
		DESCRIPTIVE STATISTICS I		
RUSSTA101	I	Types of Data and Data Condensation	2	1
	II	Measures of central tendency		1
	III	Measures of Dispersion, Skewness & Kurtosis		1
Course Code	UNIT	TITLE	Credits	L / Week
		STATISTICAL METHODS - I		
RUSSTA102	I	Elementary Probability Theory	2	1
	II	Discrete random variable		1
	III	Some Standard Discrete Distributions		1
	Practical based on courses above		2	6

SEMESTER II

Course Code	UNIT	TITLE	Credits	L / Week
		DESCRIPTIVE STATISTICS II		
RUSSTA201	I	Correlation and Regression Analysis	2	1
	II	Time Series		1
	III	Index Numbers		1
Course Code	UNIT	TITLE	Credits	L / Week
		STATISTICAL METHODS – II		
RUSSTA202	I	Continuous random variable and Standard Continuous Distribution	2	1
	II	Normal Distribution		1
	III	Elementary topics on Estimation and Testing of hypothesis		1
	Practical based on courses above		2	6

COURSE: **DESCRIPTIVE STATISTICS I**

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 • 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) and measures of association with the help of Tau B, Tau C, Gamma and Lambda • 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
Unit II–Measures of central tendency • Concept of central tendency of data, Requirements of good measures of central tendency. • 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.	15 Lectures
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

COURSE: STATISTICAL METHODS - I

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
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. • Concepts of Skewness and Kurtosis and their uses. • Expectation of a random variable. Theorems on Expectation & Variance. Concept of Generating function, Moment Generating function, Cumulant generating function, Probability generating function • 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.	15 Lectures
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. • Moment Generating Function and Cumulant Generating Function of Binomial and Poisson distribution. • Recurrence relationship for probabilities of Binomial and Poisson distributions, Poisson approximation to Binomial distribution, Binomial approximation to hypergeometric distribution.	15 Lectures

COURSE: DESCRIPTIVE STATISTICS II

UNIT – I: Correlation, Simple linear Regression Analysis and Fitting of curves • Visualizing relationship using Bubble chart, Scatter Diagram, • Karl Pearson's Product moment correlation coefficient and its properties. • Spearman's Rank correlation.(With and without ties) • 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
UNIT – II : Time Series • 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	15 Lectures
Unit - III : 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

COURSE: STATISTICAL METHODS – II

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. Concept of M.G.F. and C.G.F. characteristics. 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, MG.F. and C.G.F. for Uniform and Exponential distributions.	15 Lectures
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 mean and sample proportion difference between two population means and two proportions. • Standard errors of sample mean and sample proportion.	15 Lectures
UNIT – VI: 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

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 PitanJim:“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

Distribution of topics for Practicals in Semester I

Course Code UGS.STP1A		Course Code UGS.STP1B	
Sr. No.	**Practicals based on course**	Sr. No.	**Practicals based on course**
1	Tabulation	1	Probability
2	Classification of Data	2	Discrete Random Variables
3	Attributes	3	Bivariate Probability Distributions
4	Diagrammatic representation	4	Binomial Distribution
5	Measures of central tendency	5	Poisson Distribution
6	Measures of dispersion	6	Hypergeometric Distribution
7	Practical using Excel and R i) Classification of Data and Diagrammatic representation ii) Measures of central tendency iii) Measures of dispersion	7	Practical using Excel and R i) Binomial distribution ii) Poisson distribution iii) Hypergeometric distribution

Distribution of topics for Practicals in Semester II

Course		Course	
Sr. No.	**Practicals based on course**	Sr. No.	**Practicals based on course**
1	Correlation analysis	1	Continuous Random Variables
2	Regression analysis	2	Uniform and Exponential Distributions
3	Fitting of curve	3	Normal Distribution
4	Time series	4	Sampling Distribution
5	Index number-I	5	Testing of Hypothesis
6	Index number-II	6	Large sample Tests
7	Practical using Excel and R i) Correlation analysis ii) Regression analysis iii) Fitting of curve	7	Practical using Excel and R i)Uniform and Exponential ii)Normal Distribution iii) Sampling Distribution iv) Testing of Hypotheses v) Large sample Tests

Internal Assessment of Theory Core Courses Per Semester Per Course

1. One Class Test (Objective type): ..……..20 Marks.
2. One Class Test (Objective type) / Project / Assignment / Presentation: 20 Marks.

Semester End Examination

Theory: At the end of the semester, examination of two hours duration and 60 marks based on the three units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for **each course:**

There shall be THREE COMPULSORY Questions of 20 marks each (Internal Option).

Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III.

Practical Core Courses per Semester per course

1. Documentation and Journal .....05 Marks.
2. Semester work ……05 Marks.
3. Practical Examination ……40 Marks.

At the end of the semester, examination of 2 hours duration and 40 marks shall be held for **each course**.

Pattern of **Practical question** paper at the end of the semester for **each course**:

There shall be **Four** COMPULSORY Questions.

Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III carrying 12 marks each.

Question 4 based on any unit carrying 4 marks.

Workload

Theory: 3 lectures per week per course.

Practicals: 3 lecture periods per course per week per batch. All three lecture periods of the practicals shall be conducted in succession together on a single day.

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RAMNARAIN RUIA AUTONOMOUS COLLEGE
MATUNGA, MUMBAI

Syllabus for the S.Y.B.Sc.
Program: B.Sc.
Course: STATISTICS

(Credit Based Semester and Grading System with effect from the academic year 2017–2018)

Objective of Course

In the second year, there will be three courses in Statistics per semester. The following are the objectives of these courses:

6. To enable learners with the concepts of probability distributions and its applications.
7. To equip learners with methods of sampling and designs of experiments
8. To use different sampling techniques and designs of experiments in various real life situations.
9. To equip learners with requisite optimization techniques that they can employ.
10. To understand statistical quality control techniques and its applications using mathematical methods and their graphical representation.

Learning Outcomes

5. Learners will be able to choose and apply appropriate statistical techniques to solve problems in different fields.
6. Learners will be able to use statistical tools to solve problems from different fields.
7. Student will be able to engage in interpretation of wide range of information from variety of disciplines including quantitative analysis.
8. Learners will be able to use optimization techniques in real life situation
9. Learners will be able to employ statistical quality control techniques in various fields.

SEMESTER III

Title of the course	PROBABILITY DISTRIBUTIONS			
Course Code	**UNIT**	**TOPICS**	**Credits**	**L / Week**
	I	Standard Discrete Probability Distributions	2	1
	II	Bivariate Probability Distributions		1
	III	Standard Continuous Probability Distributions		1
Title of the course	**THEORY OF SAMPLING**			
	I	Concepts of Sampling and Simple Random Sampling	2	1
	II	Stratified Sampling		1
	III	Ratio and Regression Estimation		1
Title of the course	**OPERATIONS RESEARCH**			
	I	Linear Programming Problem.	2	1
	II	Transportation Problem.		1
	III	Assignment & Sequencing Problem.		1
	Practical based on courses above		3	9

SEMESTER III

Course Code: PROBABILITY DISTRIBUTIONS

Unit I : Standard Discrete Probability Distributions: • Binomial Distribution, Poisson Distribution: Derivation of Mode using probability recurrence relation, Truncated Distribution at Zero, Suitable illustrations, probability mass function. Mean and Variance of Truncated Distribution, Recurrence relation for central Moments, Skewness and Kurtosis (without proof). • Geometric Distribution, Negative Binomial Distribution: Moment Generating Function, Cumulant generating Function, Their important properties. Additive property, Recurrence relation for central Moments, Skewness and Kurtosis (without proof), Limiting distribution. • Fitting of Distribution.	**15 Lectures**
Unit II : Bivariate Probability Distributions: • Joint Probability mass function for discrete random variables**,** Joint Probability density functions for continuous random variables. Their properties. Cumulative Distribution Function. 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**
Unit III : Standard Continuous Probability Distributions: • Rectangular, Triangular, Exponential, Cauchy (with location & Scale parameter), Gamma (with scale & shape parameter), Beta (Type I & Type II). • The following aspects of the above distributions (wherever applicable) to be covered: Graphical representation of p.d.f. and c.d.f. Mean, Median, Mode & Standard deviation. Moment Generating Function, Additive property, Cumulant Generating Function. Skewness and Kurtosis. • Fitting of Distribution.	**15 Lectures**

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: THEORY OF SAMPLING

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
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
Unit III : a. Ratio & Regression Estimation assuming SRSWOR: • Ratio Estimators for population Ratio, Mean & 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. **b. Introduction to Systematic sampling, Cluster sampling & Two Stage sampling with suitable illustrations**.	15 Lectures

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: OPERATIONS RESEARCH

Unit I : Linear Programming Problem (L.P.P.) : • Mathematical Formulation: Maximization & 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.	**15 Lectures**
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**
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**

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

DISTRIBUTION OF TOPICS FOR PRACTICALS
SEMESTER-III
COURSE CODE

Sr. No.	Semester III
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.
7	Applications of R.

Sr. No.	Semester III
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.
7	Regression Estimation.

Sr. No.	Semester III
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.

SEMESTER IV

Title of course	**PROBABILITY AND SAMPLING DISTRIBUTIONS**			
Course code	**UNIT**	**TOPICS**	**Credits**	**L / Week**
	I	Standard Continuous Probability Distributions	2	1
	II	Normal Distribution.		1
	III	Exact Sampling Distributions		1
Title of course	**ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS**			
	I	Analysis of Variance.	2	1
	II	Design Of Experiments, Completely Randomized design & Randomized Block Design		1
	III	Latin Square Design & Factorial Experiments		1
Title of course	**PROJECT MANAGEMENT AND INDUSTRIAL STATISTICS**			
	I	CPM and PERT.	2	1
	II	Control charts		1
	III	Lot Acceptance Sampling Plans By Attributes.		1
	Practical based on courses UGS.ST401, UGS. ST402 & UGS.ST403		3	9

Semester IV

Course Code: PROBABILITY AND SAMPLING DISTRIBUTIONS

Unit I: Normal Distribution: • Generating function, Moments & Cumulants (up to fourth order). Recurrence relation for central moments, skewness & kurtosis, Mean absolute deviation. Distribution of linear function of independent Normal variables. Fitting of Normal Distribution. • Central Limit theorem for i.i.d. random variables.(With Proof) • Log Normal Distribution: Derivation of mean & variance.	**15 Lectures**
Unit II: Chi-Square Distribution: • Concept of degrees of freedom. Definition of Chi-square variable and its p.d.f. Mean, Median, Mode & Standard deviation. Moment generating function, Cumulant generating function. • Additive property, Derivation of p.d.f. of Chi-square variate. Sampling distributions of sample mean and sample variance and their independence for a sample drawn from Normal distribution. **Applications of Chi-Square Distribution:** • Confidence interval for the variance of a Normal population, • Test of significance for specified value of variance of a Normal population. • Test for goodness of fit, Test for independence of attributes. Yates' correction.	**15 Lectures**
Unit III: t-distribution: • Definition of Fisher's t variable and its p.d.f. Mean, Median, Mode & Standard deviation. Asymptotic properties. Student's t. **Applications of t Distribution:** • 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. (ii) dependent samples). **F-distribution:** • Definition of F and its p.d.f**.** (Snedecor's F) Mean, Mode & Standard deviation. Distribution of Reciprocal of 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 Distribution:** • Confidence interval for ratio of variances of two independent Normal populations. • Test for equality of variances of two independent Normal populations.	**15 Lectures**

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: ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS

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**
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. • 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 a CRD.	**15 Lectures**
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 CRD, RBD & 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.	**15 Lectures**

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: PROJECT MANAGEMENT AND INDUSTRIAL STATISTICS

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**
Unit II : Statistical Quality Control-I: • Principles of control. Process quality control of attributes and variables. *X* bar and R, p, c, np charts and their uses. p-chart with variable sample size. Problems involving setting up standards for future use. • Concept of Natural Tolerance Limits, Specification Limits and Detection of shift	**15 Lectures**
Unit III : Statistical Quality Control-II: • Exponentially weighted moving average (EWMA) control charts, Cumulative Sum (CUSUM) control chart, Introduction to Six sigma limits. • Single Sampling Plans (without curtailment). • OC function and OC curves. AQL, LTPD, ASN, ATI, AOQ, Consumer's risk, Producer's risk. • Double Sampling Plan (Concept only)	**15 Lectures**

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. (6^{th} 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

DISTRIBUTION OF TOPICS FOR PRACTICALS
SEMESTER-IV
COURSE CODE

Sr. No.	Course Code: PROBABILITY AND SAMPLING DISTRIBUTIONS
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, R software

Sr. No.	Course Code: ANALYSIS OF VARIANCE & DESIGN OF EXPERIMENTS
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 and R software

Sr. No.	Course Code: PROJECT MANAGEMENT AND INDUSTRIAL STATISTICS
1	PERT
2	CPM
3	Project cost analysis
4	Updating
5	Control Charts for attributes
6	Control Charts for variables
7	Acceptance Sampling Plans.
8	Practical using TORA software

Internal Assessment of Theory Core Courses Per Semester Per Course

1. One Class Test (Objective type): ..……..20 Marks.
2. One Class Test (Objective type) / Project / Assignment / Presentation: ……. ..20 Marks.

Semester End Examination

Theory: At the end of the semester, examination of two hours duration and 60 marks based on the three units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for ***each course:***

There shall be THREE COMPULSORY Questions of 20 marks each (Internal Option).

Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III.

Practical Core Courses per Semester per course

1. Documentation and Journal ..……05 Marks.
2. Semester work ……05 Marks.
3. Practical Examination ……40 Marks.

At the end of the semester, examination of 2 hours duration and 40 marks shall be held for **each course**.

Pattern of **Practical question** paper at the end of the semester for **each course**:

There shall be **Four** COMPULSORY Questions.

Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III carrying 12 marks each.

Question4 based on any unit carrying 4 marks.

Workload

Theory: 3 lectures per week per course.

Practicals: 3 lecture periods per course per week per batch. All three lecture periods of the practicals shall be conducted in succession together on a single day.

****

Resolution No.: AB/I(17-18).3.RUS11

RAMNARAIN RUIA AUTONOMOUS COLLEGE
MATUNGA, MUMBAI

Syllabus for the T.Y.B.Sc.
Program: B.Sc.
Course: STATISTICS

(Credit Based Semester and Grading System with effect from the academic year 2017–2018)

Objective of Course

In the third year, there will be two core courses in Statistics per semester and two applied courses in Statistics. The following are the objectives of these courses:

11. To understand basic and advance concepts of Probability theory and their applications
12. To enable learners to understand Statistical Inference and its applications.
13. To teach learners applications of Statistics in Biology, Clinical trials and Bioequivalence, Annuities and Assurance.
14. To equip learners with requisite quantitative skills with the use of software.
15. To understand and have skill in optimisation techniques and queuing.
16. To develop presentation and communication skills

Learning Outcomes

10. Learners will be able to use and apply theory of probability and statistical inference

11. Learners will be able to use statistical techniques in applied fields.

12. Learners will be able to use statistical software tools to solve problems from different fields.

13. Student will be able to engage in interpretation of wide range of information from variety of disciplines including quantitative analysis.

SEMESTER V

Title of the course	PROBABILITYAND DISTRIBUTIONTHEORY			
Course Code	UNIT	TOPICS	Credits	L / Week
	I	Probability-I	2.5	1
	II	Probability-II		1
	III	Joint Moment Generating Function Trinomial & Multinomial Distribution		1
	IV	Order Statistics		1
Title of the course	THEORY OF ESTIMATION			
	I	Point Estimation and Properties of Estimator- I	2.5	1
	II	Properties of Estimator- II		1
	III	Methods of Estimation		1
	IV	Bayesian Estimation and Confidence Interval		1
Title of the course	BIOSTATISTICS			
	I	Epidemic Models	2.5	1
	II	Bioassay		1
	III	**Clinical Trials**		1
	IV	Bioequivalence-I		1
Title of the course	ELEMENTS OF ACTUARIAL SCIENCE			
	I	Mortality Tables	2.5	1
	II	Compound Interest And Annuities Certain		1
	III	Life Annuities		1
	IV	Assurance Benefits		1

Course	PRACTICALS	Credits	L / Week
	Practicals based on theory Courses	3	8
	Practicals based on theory Courses	3	8

Course Code: PROBABILITYAND DISTRIBUTIONTHEORY

Unit I : PROBABILITY-I: • Basic definitions: Random Experiment, Outcome, Event, Sample Space, Complementary, Mutually Exclusive, Exhaustive and Equally Likely Events. • 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 (a) two (b) three events. (Ref. 1,2,5,7,8)	**15 Lectures**
Unit II : PROBABILITY-II: • Theorems on Probability of realization of : (a) At least one (b) Exactly m (c) At least m of N events A_1, A_2, $A_3 \ldots A_N$. • Matching and Guessing problems. • Conditional Probability: Multiplication Theorem for two, three events. • Independence of two/three events - complete and pair wise. • Bayes' theorem (Ref. 1,2,5,8)	**15 Lectures**
Unit III: 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, $p_2, \ldots p_{k-1}$) 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 $X_j = x_j$ (Ref.2,3,6,7)	**15 Lectures**

Unit IV: ORDER STATISTICS	**15 Lectures**
• 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. (Ref.2,3,4)	

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.

Course Code: THEORY OF ESTIMATION:

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. (Ref. 1,3,8)	**15 Lectures**
<u>Unit II</u> : <u>PROPERTIES OF ESTIMATOR- II</u> • 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. (Ref: 1,2,3)	**15 Lectures**
<u>Unit III</u> : <u>METHODS OF ESTIMATION</u> • 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)	**15 Lectures**

• 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. (Ref. 1, 3, 8)	
Unit IV: 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. (Ref: 1, 2, 3)	**15 Lectures**

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: BIOSTATISTICS:

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. (Ref.1)	**15 Lectures**
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. (Ref.2,3)	**15 Lectures**
Unit III: CLINICAL TRIALS: AN INTRODUCTION • Introduction to clinical trials: The need and ethics of clinical trials. 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). • Types of Trials: Inferiority, Superiority and Equivalence, Multicentric Trial. Inclusion/Exclusion Criteria. Statistical tools: Analysis of parallel Design using Analysis of Variance. • Concept of odds ratio. Sample size estimation. (Ref. 4,5,6,7,8)	**15 Lectures**
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, Cross over (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). (Ref. 9)	**15 Lectures**

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, 7^{th} 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.

Course Code: ELEMENTS OF ACTUARIAL SCIENCE :

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. (Ref.2,3)	**15 Lectures**
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 arithmetic progression • (iii) annuity with Frequency different from that with which interest is convertible. Redemption of loan. (Ref.2)	**15 Lectures**
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). (Ref:1,2)	**15 Lectures**
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 • Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. • Office premiums. (Ref:1,2)	**15 Lectures**

***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.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-V

COURSE CODE UGS.STP5

Sr. No.	Practical Topics
5.1.1	Probability-1
5.1.2	Probability -2
5.1.3	Probability -3
5.1.4	Multinomial Distribution
5.1.5	Order Statistics -1
5.1.6	Order Statistics -2

Sr. No.	Practical Topics
5.2.1	MVUE and MVBUE
5.2.2	Method of Estimation -1
5.2.3	Method of Estimation -2
5.2.4	Bayes' Estimation
5.2.5	Confidence Interval
5.2.6	Use of R software

COURSE CODE UGS.STP6

Sr. No.	Practical Topics
5.3.1	Epidemic models
5.3.2	Direct Assays
5.3.3	Quantal Response Assays
5.3.4	Parallel line Assay
5.3.5	Clinical Trials
5.3.6	Bioequivalence

Sr. No.	Practical Topics
5.4.1	Mortality tables 1
5.4.2	Mortality tables 2
5.4.3	Annuities 1
5.4.4	Annuities 2
5.4.5	Life annuities
5.4.6	Assurance benefits

SEMESTER VI

Title of the Course	DISTRIBUTIONTHEORY AND STOCHASTIC PROCESSES			
Course	**UNIT**	**TOPICS**	**Credits**	**L / Week**
	I	**Stochastic Processes**	**2.5**	**1**
	II	**Generating Functions**		**1**
	III	**Queuing Theory-I**		**1**
	IV	**Queuing Theory-II**		**1**
Title of the Course	**TESTING OF HYPOTHESES**			
	I	**Introduction to Testing of Hypothesis**	**2.5**	**1**
	II	**Parametric tests**		**1**
	III	**Likelihood Ratio Test and SPRT**		**1**
	IV	**Non-Parametric tests**		**1**
Title of the Course	**OPERATIONS RESEARCH TECHNIQUES**			
	I	**Inventory Control**	**2.5**	**1**
	II	**Game Theory**		**1**
	III	**Replacement**		**1**
	IV	**Decision Theory**		**1**
Title of the Course	**FORECASTING & RELIABILITY**			
	I	**Time Series**	**2.5**	**1**
	II	**Simulation**		**1**
	III	**Linear Regression**		**1**
	IV	**Reliability**		**1**

Course	PRACTICALS	Credits	L / Week
	Practicals of Course UGS.ST601 + UGS.ST602	**3**	**8**
	Practicals of Course UGS.ST603 + UGS.ST604	**3**	**8**

Course Code: DISTRIBUTION THEORY AND STOCHASTIC PROCESSES:

Unit I : 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 $\rho = 0$. 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. (Ref.1,5)	**15 Lectures**
Unit II : 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. (Ref.1,5)	**15 Lectures**
Unit III: 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. (Ref.1,7,9)	**15 Lectures**

Unit IV: QUEUING THEORY	**15 Lectures**
• Basic elements of the Queuing model. • Roles of the Poisson and Exponential distributions. • Derivation of Steady state probabilities for birth and death process. Steady state probabilities and various average characteristics for the following models: (i) (M/M/1) : (GD/ ∞ /∞), (ii) (M/M/1) : (GD/ N/∞) (iii) (M/M/c) : (GD/ ∞/ ∞), (iv) (M/M/c):(GD/ N /∞) (v) (M/M/∞) : (GD/ ∞ /∞) (Ref.6)	

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: TESTING OF HYPOTHESES

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. (Ref. 1,2)	**15 Lectures**
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) Ref. (1,2,3)	**15 Lectures**
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. (Ref. 1,6,8,9)	**15 Lectures**
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. Single sample and two sample Nonparametric tests. (i) Sign test (ii) Wilcoxon's signed rank test (iii) Median test (iv) Mann–Whitney test (v) Run test. • Assumptions, justification of the test procedure for small & large samples. (Ref.5)	**15 Lectures**

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: OPERATIONS RESEARCH TECHNIQUES

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 at most 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. (Ref. 1,2,3,)	**15 Lectures**
Unit II : 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. (Ref. 1)	**15 Lectures**
Unit III: REPLACEMENT • Replacement of items that deteriorate with time and value of money that remains constant and that changes with time. • Replacement of items that fail completely: Individual replacement and Group replacement policies. (Ref. 5)	**15 Lectures**
Unit IV: 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. Bayesian Decision rule for Posterior analysis. • Decision tree analysis along with Posterior probabilities. (Ref.1)	**15 Lectures**

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

Course Code: FORECASTING & RELIABILITY

Unit I : TIME SERIES • Definition of Time series. Its components. Models of Time Series. • Estimation of trend by: (i) Freehand curve method (ii) Method of Semi Averages (iii) Method of Moving Averages (iv) Method of Least Squares (v) Exponential Smoothing method • Estimation of seasonal component by: (i) Method of simple averages (ii) Ratio to moving average method (iii) Ratio to trend method (Ref: 8,9)	**15 Lectures**
Unit II : SIMULATION • Scope of simulation applications. Types of simulation. Monte Carlo Technique of Simulation. • 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. • Simulation techniques applied to inventory and Queuing models. (Ref.4,5)	**15 Lectures**

Unit III: LINEAR REGRESSION
• 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.
• 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)
(Ref: 8,9)
	15 Lectures

Unit IV: RELIABILITY	**15 Lectures**
• 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). (Ref 6,7)	

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.

DISTRIBUTION OF TOPICS FOR PRACTICALS

SEMESTER-VI

COURSE CODE

Sr. No.	Practical Topics
6.1.1	Bivariate Normal Distribution
6.1.2	Tests for correlation and Interval estimation
6.1.3	Generating Function
6.1.4	Stochastic Process
6.1.5	Queuing Theory -1
6.1.6	Queuing Theory -2

Sr. No.	Practical Topics
6.4.1	Time series-1
6.4.2	Time series-2
6.4.3	Simulation
6.4.4	Reliability
6.4.5	Multiple regression model -1
6.4.6	Multiple regression model- 2

COURSE CODE UGS.STP8

Sr. No.	Practical Topics
6.3.1	Inventory-1
6.3.2	Inventory-2
6.3.3	Game Theory
6.3.4	Replacement
6.3.5	Decision Theory-1
6.3.6	Decision Theory-2

Sr. No.	Practical Topics
6.2.1	Testing of Hypothesis 1
6.2.2	Testing of Hypothesis-2
6.2.3	SPRT
6.2.4	Non Parametric test-1
6.2.5	Non Parametric test-2
6.2.6	Use of R software.

Internal Assessment of Theory Core Courses Per Semester Per Course

1. One Class Test (Objective type): …..20 Marks.
2. One Class Test (Objective type) / Project / Assignment / Presentation: …20 Marks.

Semester End Examination- THEORY

At the end of the semester, examination of two hours duration and 60 marks based on the four units shall be held for each course.

Pattern of **Theory question** paper at the end of the semester for ***each course***:

There shall be **Four** compulsory Questions of **Fifteen** marks each with internal option. Question1 based on Unit I, Question 2 based on Unit II, Question 3 based on Unit III, Question 4 based on Unit IV.

Semester End Examination- PRACTICALS

At the end of the semester, examination of two hours duration and 50 marks ($40+5^{*}+5^{**}$) shall be held for **each course** as shown below.

Practical course	Questions based on	Duration	Marks out of	Will be conducted at the end of
		2 hours	40	Semester V
		2 hours	40	Semester V
		2 hours	40	Semester V
		2 hours	40	Semester V
		2 hours	40	Semester VI
		2 hours	40	Semester VI
		2 hours	40	Semester VI
		2 hours	40	Semester VI

*1.Semester work, Documentation, Journal ….5Marks.
**2. Viva ….5 Marks.

Pattern of **Practical question** paper at the end of the semester for **each course**:
Every paper will consist of two parts A and B. Every **part** will consist of two questions of 20 marks each. Learners to attempt one question from each part.

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