

Resolution: - BOS/ 19.11.22

Bharatiya Vidya Bhavan's

**M. M. College of Arts, N.M. Institute of Science, H.R.J.
College of Commerce. (Bhavan's College) Autonomous**

(Affiliated to University of Mumbai)



Syllabus for: T.Y.B.Sc.(Statistics)

Program: B.Sc.

Program Code: BH. BSc.

Course Code: BH. USST

Choice Based Credit System (CBCS)

with effect from academic year 2023-24



PROGRAM OUTCOMES

| | |
|-------------|---|
| PO | A learner completing bachelor's degree in science program will be able to acquire the following: |
| PO-1 | Disciplinary Knowledge: Capable of demonstrating comprehensive knowledge and understanding of one or more other disciplines that form a part of an undergraduate programme of study. This programme helps students in building a solid foundation for further higher studies and research. |
| PO-2 | Critical Thinking & Competency in Skills: Take informed actions after identifying the assumptions that frame our thinking and actions. Critically evaluate practices, policies, and theories by following scientific approach to knowledge development. Obtain proficiency in analytical reasoning, critical understanding, analysis, and synthesis in order to solve theoretical and practical problems. This can orient students towards applications of their subject in other disciplines and, can also be utilized in modelling and solving real life problems. |
| PO-3 | Communication Skills: Ability to express thoughts and ideas effectively in writing and orally; communicate with others using appropriate media; confidently share one's views and express herself/ himself; demonstrate the ability to listen carefully; and present complex information in a clear and concise manner to different groups. |
| PO4 | Social Interaction: Ability to work effectively and respectfully with diverse teams; facilitate cooperative or coordinated effort on the part of a group and act together as a group or a team in the interests of a common cause. Elicit views of others, mediate disagreements and help reach conclusions in group settings. |
| PO5 | Environment and Sustainability: Understand the issues of environmental contexts and sustainable development. |
| PO6 | Interdisciplinary and Research Skills: A sense of inquiry and capability for asking relevant/ appropriate questions, Ability to recognize cause- and-effect relationships, define problems, formulate hypotheses, interpret and draw conclusions from data, ability to plan, execute and report the results of an experiment or investigation which will enable them to apply one's learning to real life situations. |
| PO7 | Proficiency in Employments: This programme will help students to enhance their employability for Government jobs, related to science, data analysis jobs, and jobs in various other public and private enterprises. |

PROGRAM SPECIFIC OUTCOMES

| PSO | DESCRIPTION |
|--------------|---|
| | A learner completing bachelor's degree in B.Sc. program in the subject of Statistics will be able to |
| PSO-1 | use elementary tools using electronic spreadsheets in Descriptive Statistics and Statistical Methods, as the learner offers for the first time in his educational career, the subject Statistics as an Independent Subject. |
| PSO-2 | have sound mathematical base for various Statistical Methods such as Standard Discrete & Continuous Probability Distributions, Exact Sampling Distributions, Sampling Techniques, ANOVA Techniques and further exploring applied nature of subject by receiving exposure to some optimization techniques. |
| PSO-3 | Gain comfortable level of confidence in using statistical software. |
| PSO-4 | have rigorous mathematical basis to various inferential statistical methods such as Estimation, Testing of Hypotheses, Distribution Theory & Stochastic Processes, Biostatistics and Operations Research techniques. |
| PSO-5 | inculcate sound logical thinking due to exposure to advanced topics in Probability. |
| PSO-6 | make learner industry ready due to use R software/Python programming in theory papers/skill enhancement papers. |

BSc (Statistics): Rationale behind Revision of Syllabus

To create sound theoretical (mathematical) base for various Statistical Methods and to learn their applications using Open Source/Licensed Statistical Software/packages by teaching the subject right from scratch to major techniques in Inferential Statistics which are useful in exploratory data analysis.

In view of rationale,

- First year Syllabus gives emphasis on learning of elementary topics in Descriptive Statistics and Statistical Methods, as the learner offers for the first time in his educational career, the subject Statistics as an **Independent Subject**. Data analysis using spreadsheets in one component in practical. Syllabus offered by University of Mumbai has been reorganized under Autonomy.
- Second year syllabus would expose learner to sound mathematical base for various Statistical Methods such as Standard Discrete & Continuous Probability Distributions, Exact Sampling Distributions, Sampling Techniques, ANOVA Techniques and further exploring applied nature of subject by teaching them some optimization techniques. Data analysis using R software would be one component in practical.
- Third year syllabus would extend more rigorous mathematical basis to various inferential statistical methods such as Estimation, Testing of Hypotheses, Distribution Theory & Stochastic Processes and Operations Research techniques. Syllabus would also give exposure to advanced topics in Probability which inculcates sound logical thinking in the learners. Learner shall also be exposed to field of Actuarial Science by teaching them basics in field of demography & Insurance. R software/Python programming would find scope in theory papers/skill enhancement papers apart from practical to make learner industry ready.

PROGRAM OUTLINE FOR BSc

| Sem ester | Core course 14 CREDIT(T+P) =2+1 /COURSE | Ability enhancement course CREDIT 2 | Skill enhancement course CREDIT 2 | Discipline specific elective* CREDIT 3 | Generic elective CREDIT04 | TOTAL CREDIT S |
|------------|--|--|---|--|--|----------------|
| I | C1: Paper 101 of 3 courses selected | English Communication / Environmental Sc (FC) | | | | 20 |
| | C2: Paper 102 of 3 courses selected | | | | | |
| II | C3: Paper 201 of 3 courses selected | English Communication / Environmental SC (FC) | | | | 20 |
| | C4: Paper 202 of 3 courses selected | | | | | |
| III | C5: Paper 301 of 2 courses selected | | (FC) | | (SWAYAM/ Coursera) Optional for ECC | 20 |
| | C6: Paper 302 of 2 courses selected | | | | | |
| | C7: Paper 303 of 2 courses selected | | | | | |
| IV | C8: Paper 401 of 2 courses selected | | SEC2 (FC) | | GE4 (SWAYAM/ Coursera) Optional for ECC | 20 |
| | C9: Paper 402 of 2 courses selected | | | | | |
| | C10: Paper 403 of 2 courses selected | | | | | |
| V | C11: Paper 501 of 1 course selected 3 Credits | | Practicals based on 2 papers(C11 &12) - 2 Credits | Paper 503 of 1 course selected - 3 Credits | Applied component T+ P (3+1=4 credits) | 20 |
| | C12: Paper 502 of 1 course selected 3 Credits | | Practicals based on 2 DSE papers- 2 Credits | Paper 504 of 1 course selected - 3 Credits | | |
| VI | C13: Paper 601 of 1 course selected 3 Credits | | Practicals based on 2 papers(C13 &14) - 2 Credits | Paper 603 of 1 course selected - 3 Credits | Applied component T+P (3+1=4 credits/EC | 20 |

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|--|--|--|---|--|--|------------|
| | | | | | | |
| | C14: Paper 602 of 1 course selected 3 Credits | | Practicals based on 2 DSE papers- 2 Credits | Paper 604 of 1 course selected - 3 Credits | | |
| | TOTAL CREDITS | | | | | 120 |

Note-

- 1. The final year B.Sc. students will have the options under DSE (Discipline specific Elective) to drop of one the core paper and do dissertations under the guidance of the departmental faculty/ Any research institute of national importance for both semester V & VI.**
- 2. CBCS system will allow the students from science streams in their final year to study the applied component of any of the science subjects available in the college (E.g.- Final year Botany student can have the choice to select any one of the Applied components available with Zoology, Microbiology, Chemistry, Statistics, Physics, Mathematics, etc.).**

Students in semester- III & IV will have the option for selecting the Generic elective (GE) courses prescribed by Swayam/ Coursera/ etc. The students will be evaluated by conducting examinations at college level. The students will also have the options to get certificate from SYAWAM by qualifying their proctored examination.



PROGRAM OUTLINE

| YEAR | SEMESTER | COURSE TYPE | COURSE CODE | COURSE TITLE | CREDITS |
|-------|----------|------------------------------|-------------|---|---------|
| FYBSc | I | CoreCourse | BH. USST101 | Descriptive Statistics I | 02 |
| FYBSc | I | CoreCourse | BH. USST102 | Statistical Methods II | 02 |
| FYBSc | I | CoreCourse | BH. USSTP01 | Practical Based on BH. USST101 & BH. USST102 | 02 |
| FYBSc | II | CoreCourse | BH. USST201 | Descriptive Statistics I | 02 |
| FYBSc | II | CoreCourse | BH. USST202 | Statistical Methods II | 02 |
| FYBSc | II | CoreCourse | BH. USSTP02 | Practical Based on BH. USST201 & BH. USST202 | 02 |
| SYBSc | III | CoreCourse | BH. USST301 | Probability Distributions | 02 |
| SYBSc | III | CoreCourse | BH. USST302 | Theory of Sampling | 02 |
| SYBSc | III | CoreCourse | BH. USST303 | Operations Research I | 02 |
| SYBSc | III | CoreCourse | BH. USSTP03 | Practical Based on BH. USST301, BH. USST302 & BH. USST303 | 03 |
| SYBSc | IV | CoreCourse | BH. USST401 | Probability & Sampling Distributions | 02 |
| SYBSc | IV | CoreCourse | BH. USST402 | Analysis of Variance & Designs of Experiments | 02 |
| SYBSc | IV | CoreCourse | BH. USST403 | Operations Research II | 02 |
| SYBSc | IV | CoreCourse | BH. USSTP04 | Practical Based on BH. USST401, BH. USST402 & BH. USST403 | 03 |
| TYBSc | V | CoreCourse | BH. USST501 | Probability and distribution theory | 03 |
| TYBSc | V | CoreCourse | BH. USST502 | Theory of Estimation | 03 |
| TYBSc | V | Discipline specific elective | BH. USST503 | Biostatistics | 03 |
| TYBSc | V | Discipline specific elective | BH. USST504 | Regression Analysis using R Software | 03 |
| TYBSc | V | Skill enhancement course | BH. USSTP05 | Practical Based on BH. USST501 & BH. USST502 | 02 |
| TYBSc | V | Skill enhancement course | BH. USSTP06 | Practical Based on BH. USST503 & BH. USST504 | 02 |

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|-------|----|------------------------------|---------------|--|----|
| TYBSc | V | Generic elective | BH.USACOR501 | Elements Of Operations Research I | 02 |
| TYBSc | V | Generic elective | BH. USACOR5P1 | Practical Based on BH. USACOR501 | 02 |
| TYBSc | VI | CoreCourse | BH. USST601 | Distribution Theory and Stochastic Processes | 03 |
| TYBSc | VI | CoreCourse | BH. USST602 | Testing of Hypotheses | 03 |
| TYBSc | VI | Discipline specific elective | BH. USST603 | Operations Research Techniques | 03 |
| TYBSc | VI | Discipline specific elective | BH. USST604 | Elements Of Actuarial Science | 03 |
| TYBSc | VI | Skill enhancement course | BH. USSTP07 | Practical Based on BH USST601 & BH. USST602 | 02 |
| TYBSc | VI | Skill enhancement course | BH. USSTP08 | Practical Based on BH USST603 & BH. USST604 | 02 |
| TYBSc | VI | Generic elective | BH. USACOR601 | Elements Of Operations Research II | 02 |
| TYBSc | VI | Generic elective | BH. USACOR6P1 | Practical Based on BH USACOR601 | 02 |

DETAILED SYLLABUS – SEMESTER V & VI

PREAMBLE

BSc (Statistics) Program would create sound theoretical (mathematical) base for various Statistical Methods and to learn their applications using Open Source/Licensed Statistical Software/packages by teaching the subject right from scratch to major techniques in Inferential Statistics which are useful in exploratory data analysis.

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|--|--|--|------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: V | |
| Course: Statistics Paper I (PROBABILITY AND DISTRIBUTION THEORY) | | | | Course Code: BH.USST501 | |
| Teaching Scheme | | | | Evaluation Scheme (Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory+ Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: Terminology of Probability, Types of Random variables, and their Probability Distributions. | | | | | |
| Course Objectives: | | | | | |
| <ol style="list-style-type: none"> 1. To strengthen students' concepts in mathematical statistics and distribution theory. 2. To introduce students to the concepts of PGF. 3. To introduce students to the concept of Order statistics, its importance and applications in real life situations. | | | | | |
| Course Outcomes: | | | | | |
| The learner would be able to: | | | | | |
| <ol style="list-style-type: none"> 1. Solve occupancy and matching problems. 2. Obtain bounds on probability and use the knowledge of PGF to compute probabilities for different problems. 3. Know the use of Trinomial and Multinomial distributions. 4. Solve different types of problems based on the Bivariate Normal Distribution. 5. Obtain distribution of order statistics and apply in real life situations. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | Probability: Definition: Mathematical, Statistical, Axiomatic and Subjective probability. Theorems on Probability of realization of (i) at least one. (ii) exactly m (iii) at least m events out of N events $A_1, A_2, A_3 \dots A_N$. Boole's Inequality. Maxwell Boltzmann, Bose Einstein and Fermi Dirac statistics Ordered samples and Runs. Occupancy problems, Matching and guessing problems. Conditional probability, Bayes' theorem and its application. | | | | 15 |
| II | GENERATING FUNCTIONS Univariate 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 |

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| | <p>BIVARIATE MOMENT GENERATING FUNCTION: Definition and properties of Moment Generating Function (MGF) of two random variables of discrete and continuous type. Necessary and Sufficient condition for independence of two random variables. Concept and definition of Bivariate MGF.</p> | |
| III | <p>BIVARIATE NORMAL DISTRIBUTION TRINOMIAL DISTRIBUTION & MULTINOMIAL DISTRIBUTION AND 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.</p> <p>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.</p> <p>Correlation coefficient between (X, Y). Distribution of the Sum $X+Y$ Extension to Multinomial distribution with parameters $(n, p_1, p_2, \dots, p_{k-1})$ where $p_1 + p_2 + \dots + p_{k-1} + p_k = 1$. Expression for joint MGF. Derivation of: joint probability distribution of (X_i, X_j). Conditional probability distribution of X_i</p> | 15 |
| IV | <p>ORDER STATISTICS For CONTINUOUS RANDOM VARIABLE (i) Definition of Order Statistics based on a random sample. (ii) 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 functions of all n ordered statistics. (e) Distribution of Maximum observation (n^{th} order statistic) and Minimum observation (first order statistic) in case of uniform and Exponential distribution. (f) Correlations coefficient between the i^{th} and j^{th} order statistics of the uniform distribution (g) Distribution of range and median (n odd) for the Uniform and Exponential distribution</p> <p>For DISCRETE RANDOM VARIABLE: Distribution of min and max observation in case of Discrete Uniform and Geometric Distribution.</p> | 15 |
| | Total | 60 |

Reference Books:

1. Feller W: An introduction to probability theory and its 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. & 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. V K Rohatgi: An Introduction to probability and Mathematical Statistics.
10. H. A. David, H. N. Nagaraja: Order Statistics, Third Edition, Wiley

List of Topics for the practical:

| Title of Practical | No. of Pract. |
|---|----------------------|
| Probability - I | 1 |
| Probability - II | 1 |
| Generating Function | 1 |
| Trinomial And Multinomial Distribution | 1 |
| Bivariate Normal Distribution | 1 |
| Order Statistics (Discrete and Continuous Cases) | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by the teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

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|---|--|--|------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: V | |
| Course: Statistics Paper II (Theory of Estimation) | | | | Course Code: BH. USST502 | |
| Teaching Scheme | | | | Evaluation Scheme (Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory+ Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: Standard discrete and continuous distributions, their properties. Basics of Matrix Algebra. | | | | | |
| Course Objectives: | | | | | |
| <ol style="list-style-type: none"> 1. To learn properties of good estimators and learn the criteria of comparing estimators 2. To learn various method of estimation and their scope & limitations of applications, 3. To learn basic concepts of linear models and apply to solve numerical examples. | | | | | |
| Course Outcomes: | | | | | |
| <ol style="list-style-type: none"> 1. Learners will get a good theoretical base and will be able to apply methods of estimation, compare estimators obtained by various methods. 2. Learner will be able to design full rank linear models and carry out its analysis | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| | <p><u>POINT ESTIMATION AND PROPERTIES OF ESTIMATORS:</u></p> <p>Notion of a Parameter and Parameter Space. Problem of Point estimation. Definitions: Statistic, Estimator and Estimate. Properties of a good estimator</p> <p>Unbiasedness: Definition of an unbiased estimator, Illustrations, and examples. Properties of Unbiased Estimator. Two distinct unbiased estimators of $U(\theta)$ give rise to infinitely many unbiased estimators.</p> <p>Consistency: Definition of Consistency. Sufficient condition for consistency, proof & Illustrations</p> <p>Sufficiency: Concept and Definition of sufficient statistic. Neyman's Factorization theorem (without proof). Exponential family of probability distributions and sufficient statistics. (Example of a statistic which is Not Sufficient)</p> <p>Relative efficiency_of an estimator & illustrative examples.</p> <p>Minimum Variance Unbiased Estimator (MVUE) and Cramer Rao Inequality: Definition of MVUE, Uniqueness property of MVUE. Fisher's information function, Regularity conditions. Cramer-Rao inequality. Cramer-Rao lower bound (CRLB), Efficiency of an estimator using CRLB. Condition when equality is attained in Cramer Rao Inequality and its use in finding MVUE.</p> | | | | 15 |

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| II | <p><u>METHODS OF POINT ESTIMATION</u></p> <p>Method of Maximum Likelihood Estimation (M.L.E.): Definition of likelihood as a function of unknown parameter for a random sample from: Discrete distribution & Continuous distribution. Derivation of Maximum likelihood estimator (M.L.E.) for parameters of Standard distributions (case of one and two unknown parameters). Properties of MLE (without proof, (Asymptotic and Finite Sample).</p> <p>Method of Moments: Derivation of Moment estimators for standard distributions (case of one and two unknown parameters), Illustrations of situations where MLE and Moment Estimators are distinct and their comparison using Mean Square error. Properties of MoM (Asymptotic and Finite Sample).</p> <p>Methods of Minimum Chi-square and Modified Minimum Chi Square</p> | 15 |
| III | <p><u>BAYESIAN ESTIMATION METHOD & INTERVAL ESTIMATION</u></p> <p>Bayes Estimation: Prior distribution, Posterior distribution, Loss function, Risk function, Types of Loss function: Squared error Loss function (SELF), Absolute error Loss function (AELF), Bayes' risk. Bayes' method of finding Point estimator (assuming SELF),</p> <p>Examples: (i) Binomial- Beta (ii) Poisson- Gamma, (iii) Gamma-Gamma (iv) Normal-Normal</p> <p>Concept of Conjugate Prior in relation to above examples.</p> <p>Interval Estimation: Concept of confidence interval & confidence limits. Definition of Pivotal quantity and its use in obtaining confidence limits. For Normal Distribution Derivation of 100(1- α) % -equal tailed confidence interval for: (a)The population mean (population variance known/ unknown) (b) the population variance. Confidence interval based on large samples for the parameters of Binomial, Poisson, and Exponential distributions.</p> | 15 |
| IV | <p><u>INTRODUCTION TO LINEAR MODELS</u></p> <p>Explanation of General Linear Model of full rank with assumptions. Model: $Y = X\beta + \underline{e}$, where $\underline{e} \sim N(0, \sigma^2 I)$, Least squares estimator of β, their expectation and variance, estimation of error variance σ^2, BLUE of linear parametric function of β, Gauss Markoff theorem for full rank Model, expectation and variance of BLUE of linear parametric function of β, confidence interval of β_i and $l'\beta$ when σ^2 is known and unknown.</p> | 15 |
| | Total | 60 |

Reference Books:

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. Hoel P.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. A.M.Kshirsagar; Linear Models
10. F.A. Graybill; An Introduction to Linear Models
11. George Casella, Roger L. Berger: Statistical Inference, second Edition, Thompson Learning 2002.

List of Topics for the practicals:

| Topic of the Practical | No. of Practical |
|-------------------------------|-------------------------|
| MVUE | 1 |
| Methods of Estimation - I | 1 |
| Methods of Estimation - II | 1 |
| Bayes' Estimation | 1 |
| Confidence Interval | 1 |
| Linear Models | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

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|--|--|--|-------------------------------------|---|---------------------------------------|
| Programme: B. Sc. | | | | Semester : V | |
| Course: Statistics Paper III (Biostatistics) | | | | Course Code: BH.USST503 | |
| Teaching Scheme | | | | Evaluation Scheme(Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory + Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: NIL | | | | | |
| Course Objectives: | | | | | |
| 1.To understand the concept of Epidemic theory and its application 2.To understand the concept of Bioassay and its practical use 3.To understand the concept of clinical trials and its application in pharmaceutical company 4.To understand the concept of bioequivalence and its application | | | | | |
| Course Outcomes: | | | | | |
| 1. Learners will learn the concepts of the topics in the syllabus. 2. Learners will learn the practical applications of the topics. 3. Concepts learnt in the paper will help the learners in higher studies. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <u>EPIDEMIC MODELS</u> (i) The features of Epidemic spread. Definitions of various terms involved. Simple mathematical models for epidemics: Deterministic model without removals (for 'a' introductions), Carrier model. (ii) Chain binomial models. Reed-Frost and Greenwood models. Distribution of individual chains and total number of cases. Maximum likelihood estimator of 'p' and its asymptotic variance for households of sizes up to 4. | | | | 15 |
| II | <u>BIOASSAYS</u> (i) Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. (ii) Indirect assays. Dose-response relationship. Conditions 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. (iii) Quantal Response assays. Tolerance distribution. Median effective dose ED50 and LD50. Probit and Logit analysis. | | | | 15 |

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| III | <p><u>CLINICAL TRIALS-I:</u> Introduction to clinical trials: The need and ethics of clinical trials. Common terminology used in clinical trials. Overview of phases (I-IV). Introduction to ICH E9 guidelines, Study Protocol, Case record/Report form, Blinding (Single/Double) Randomized controlled (Placebo/Active controlled), Study Designs (Parallel, Cross Over). Types of Trials: Inferiority, Superiority and Equivalence, Multicentric Trial. Inclusion/Exclusion Criteria. Sample size estimation.</p> | 15 |
| IV | <p><u>CLINICAL TRIALS-II and BIOEQUIVALENCE:</u> Statistical tools: Analysis of parallel Design using Analysis of Variance. Concept of odds ratio. M-H Procedure for testing of independence of cases and risk factor. Concept of Repeated Measures Designs. Survival analysis: Introduction, Time to event data and Censoring, Statistical Distribution Functions and Hazard Function, Kaplan-Meire approach for survival analysis, Concepts of Mean survival time, Median survival time, Five year survival rate and Average hazard rate. <u>BIOEQUIVALENCE:</u> Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmacokinetic (PK) parameters C_{max}, AUC_t, $AUC_{0-\infty}$, T_{max}, K_{el}, T_{half}. Estimation of PK parameters using 'time vs. concentration' profiles. Designs in Bioequivalence: Parallel, Cross over (Concept only). 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).</p> | 15 |
| | Total | 60 |

Reference Books:

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 Boltan 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.

List of Topics for the practical:

| Topic of the Practical | No. of Practical |
|------------------------|------------------|
| Epidemic Models | 1 |
| Direct Assays | 1 |

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|-------------------------|----------|--|
| Parallel Line Assays | 1 | |
| Quantal Response Assays | 1 | |
| Clinical Trials | 1 | |
| Bioequivalence | 1 | |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)
For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

| | | | | | |
|--|---|--|------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: V | |
| Course: Statistics Paper IV (Regression Analysis using R-Software) | | | | Course Code: BH. USST504 | |
| Teaching Scheme | | | | Evaluation Scheme (Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory +Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: Basics of correlation and regression analysis. | | | | | |
| Course Objectives: | | | | | |
| <ol style="list-style-type: none"> 1. To learn basics of R-software, 2. To learn application of R-software in Simple linear regression analysis 3. To learn application of R-software in Multiple linear regression analysis 4. To understand the situation when regression analysis is valid. | | | | | |
| Course Outcomes: | | | | | |
| <ol style="list-style-type: none"> 1. Learners will be able to perform simple operations using R-software. 2. Learners will be able to perform regression analysis using R-software, 3. Learners will be able to identify situations when regression analysis can be applied. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <p><u>Fundamentals of R</u> Introduction to R, features of R, (Difference between R and Python) installation of R, Starting and ending R session, getting help in R, Value assigning to variables Basic Operations: +, -, *, ÷, ^, sqrt Numerical functions: log 10, log, sort, max, unique, range, length, var, prod, sum, summary, dim, sort, five num etc Data Types: Vector, list, matrices, array and data frame Variable Type: logical, numeric, integer, complex, character and factor Data Manipulation: Selecting random N rows, removing duplicate row(s), dropping a variable(s), Renaming variable(s), subsetting data, creating a new variable(s), selecting of random fraction of row(s), appending of row(s) and column(s), simulation of variables. Data Processing : Data import and export, setting working directory, checking structure of Data :Str(), Class(), Changing type of variable (for eg as.factor, as.numeric) Data Visualisation using ggplot: Simple bar diagram, subdivided bar diagram, multiple bar diagram pie diagram, Box plot for one and more variables, histogram, frequency polygon, scatter plot, gg plot()</p> | | | | 15 |

| | | |
|------------|---|-----------|
| II | <p><u>Simple linear regression model</u> Assumptions of the model, Derivation of ordinary least square (OLS) estimators of regression coefficients, Properties of least square estimators (without proof), MLE of the regression coefficients. Coefficient of determination R^2 and adjusted R^2, Procedure of testing</p> <p>a) Overall significance of the models b) Significance of individual coefficients c) Confidence intervals for the regression coefficients</p> <p>Data Pre-processing: Detection and treatment of missing value(s) and outliers, Interpretation of output produced by lm command in R. Weighted Least Square Method, Polynomial Regression Models.</p> | 15 |
| III | <p><u>Multiple linear regression model</u> Derivation of ordinary least square (OLS) estimators of regression coefficients for multiple regression models, Coefficient of determination R^2 and adjusted R^2, Procedure of testing</p> <p>a) Overall significance of the models, b) Significance of individual coefficients, c) Confidence intervals for the regression coefficients</p> <p>Data Pre-processing: Detection and treatment of missing value(s) and outliers, Variable selection and Model building, Interpretation of output produced by lm command in R.</p> | 15 |
| IV | <p><u>Validity of Assumptions</u></p> <p>Residual Diagnostics: Standardized residuals, Studentized residuals, residual plots, Interpretation of four plots of, Interpretation output produced by plot command in R and corrective measures such as transformation of response variable, testing normality of data .</p> <p>Autocorrelation: Concept and detection using Durbin Watson Test, Interpretation of output produced by DW-test function in R,</p> <p>Heteroscedasticity: Concept and detection using Breusch –Pagan Godfrey Test, Interpretation of output produced by bptest function in R,</p> <p>Multicollinearity: Concept and detection using R^2 and t-ratios ii) pairwise correlation between repressors iii) Variance Inflation Factor(VIF), Interpretation of output produced by mctest function in R, Consequences of using OLS estimators in presence of Autocorrelation, Heteroscedasticity and Multicollinearity, Remedial measures, Ridge Regression : Concept and case study using R</p> | 15 |
| | Total | 60 |

Reference Books:

1. Draper, N. R. and Smith, H. (1998), Applied Regression Analysis (John Wiley), Third Edition.
2. Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003), Introduction to Linear Regression Analysis (Wiley).
3. Neter, J., W., Kutner, M. H.;Nachtsheim, C.J. and Wasserman, W.(1996), Applied Linear Statistical Models, fourth edition, Irwin USA.
4. Damodar Gujrati, Sangeetha, Basic Econometrics, fourth edition, McGraw Hill Companies.
5. William Geene (1991), Econometrics Analysis, first edition, Mc Millan Publishing Company.
6. Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London

7. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition.
8. Narosa Publishing House, New Delhi.
9. Verzani, J. (2005). Using R for Introductory Statistics, Chapman and Hall /CRC Press, New York
10. Asha Jindal (Ed.) (2018), Analysing and Visualising Data with R software- A Practical Manual, Shailja Prakashan, K.C.College.

List of Topics for the practicals:

| Topic of the Practical | No. of Practical |
|---|-------------------------|
| Fundamentals of R | 1 |
| Graphs using R | 1 |
| Diagrams using R | 1 |
| Simple Linear Regression using R | 1 |
| Weighted Least Square using R | 1 |
| Multiple Linear Regression & Ridge Regression using R | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

| | | | | | |
|--|---|--|-------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: VI | |
| Course: Statistics Paper 1 (Stochastic Processes and Time Series) | | | | Course Code: BH.USST601 | |
| Teaching Scheme | | | Evaluation Scheme (Theory) | | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory + Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: NIL | | | | | |
| Course Objectives: | | | | | |
| 1. To learn advanced time series theory and application | | | | | |
| 2. To understand the concept and application of stochastic processes and queuing theory | | | | | |
| Course Outcomes: | | | | | |
| 1. Learners will be able to use time series in analyzing data and will be able to conclude about time series data. | | | | | |
| 2. Learner will learn the practical application of stochastic processes and queuing theory | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <u>STOCHASTIC PROCESSES</u> 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 wherever applicable. | | | | 15 |
| II | <u>QUEUING THEORY-I:</u> 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 / ∞). | | | | 15 |
| III | <u>QUEUING THEORY-II</u> Steady state probabilities and various average characteristics for the following models: (i) (M/M/c): (GD/ ∞ / ∞), (ii) (M/M/c) : (GD/ N/ ∞), (iii) self-serving model (M/M/ ∞) : (GD/ ∞ / ∞), (iv) Machine Servicing model (M/M/C): (GD/ k /k) | | | | 15 |
| (IV) | <u>TIME SERIES MODELS</u> Concept of stationary time series (graphical and DF test, Methods of converting non-stationary time series into stationary time series by differencing method and de-trending method, introduction to Box-Jenkins ARIMA model (5 steps). Autocorrelation function, forecasting using Box-Jenkins Methods. | | | | 15 |
| | Total | | | | 60 |

Reference Books:

1. Gupta S C & Kapoor V K: Fundamentals of Applied Statistics, Eleventh edition, Sultan Chand & Sons.
2. Taha H.A.: Operations Research: An introduction, Eighth edition, Prentice Hall of India Pvt. Ltd.
3. Medhi J: Stochastic Processes, Second edition, Wiley Eastern Ltd.
4. Brockwell, P. J. and Davis, R. A. (2003): Introduction to Time Series Analysis, Springer
5. Chatfield, C. (2001): Time Series Forecasting, Chapman &Hall. Fuller, W. A. (1996):
6. Introduction to Statistical Time Series, 2nd Ed. Wiley. Hamilton, N. Y. (1994): Time Series Analysis, Princeton University press.
7. Kendall, M. and Ord, J. K. (1990): Time Series, 3rd Ed. Edward Arnold. Lutkepohl, H. (2005): New Introduction to Multiple Time Series Analysis, Springer.

List of Topics for the practical:

| Topic of the Practical | No. of Practical |
|------------------------|------------------|
| Time Series I | 1 |
| Time Series II | 1 |
| Stochastic Process I | 1 |
| Stochastic Process II | 1 |
| Queuing Theory I | 1 |
| Queuing Theory II | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

| | | | | | |
|---|---|--|---|---|---|
| Programme: B.Sc. | | | | Semester: VI | |
| Course: Statistics Paper II (Testing of Hypotheses) | | | | Course Code: BH.USST602 | |
| Teaching Scheme | | | | Evaluation Scheme(Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial(Periods per week per batch) | Credits (Theory +Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks: 40 | Marks: 60 |
| Pre-requisites: Types of Random variables and their Probability Distributions. | | | | | |
| Course Outcomes: | | | | | |
| <ol style="list-style-type: none"> 1. Students will understand concepts of Statistical hypothesis, developing tests to test the hypothesis. 2. Formulation of Statistical hypothesis in real life situations. Apply appropriate test to validate the hypothesis. 3. Learner will be able to obtain the most powerful tests. 4. Learner will be able to solve non parametric problems. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <p>MOST POWERFUL TESTS Problem of testing hypotheses. Definitions and illustrations of i) Simple hypothesis ii) Composite hypothesis iii) Null Hypothesis iv) Alternative Hypothesis v) Test of hypothesis (Test statistics) 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 the most powerful test of size α for a simple hypothesis against a simple alternative hypothesis. Neyman-Pearson fundamental lemma. Randomized test. Standard Examples.</p> | | | | 15 |
| II | <p>UNIFORMLY MOST POWERFUL, LIKELIHOOD RATIO TESTS & FISHER'S Z – TRANSFORMATION (i) Definition, Existence and Construction of Uniformly most powerful (UMP) test (ii) 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 hypothesis) (iii) 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.</p> | | | | 15 |

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| III | <p>SEQUENTIAL PROBABILITY RATIO TESTS</p> <p>Sequential test procedure for testing a simple null hypothesis against a simple alternative hypothesis. Its comparison with fixed sample size (Neyman-Pearson) test procedure.</p> <p>Definition of Wald's SPRT of strength (α, β). Graphical/Tabular procedure for carrying out SPRT. Problems based on Bernoulli, Binomial, Poisson, Normal & Exponential distributions.</p> | 15 |
| IV | <p>NON-PARAMETRIC TESTS</p> <p>Need for non-parametric tests. Measurement scales.</p> <p>Distinction between a parametric and a non-parametric test.</p> <p>Concept of a distribution free statistic. Distribution Free Test Statistic. Single sample and two sample Nonparametric tests. (i) Sign test (ii) Wilcoxon's signed rank test (iii) Mann-Whitney test (iv) Run test (v) Fisher exact test (vi) Kruskal-Wallis test (vii) Friedman test (viii) Kolmogorov Smirnov's Test (Single and two sample test)</p> <p>Assumptions, justification of the test procedure for small & large samples</p> | 15 |
| | Total | 60 |

Reference Books:

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

List of Topics for the practicals:

| Title of the Practical | No. of Pract. |
|---|---------------|
| Testing of hypothesis | 1 |
| Tests for correlation and Interval estimation | 1 |
| SPRT | 1 |
| Non Parametric test | 2 |
| Practical using R | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

| | | | | | |
|---|--|--|-------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: VI | |
| Course: Statistics Paper III (OPERATIONS RESEARCH TECHNIQUES) | | | | Course Code: BH. USST603 | |
| Teaching Scheme | | | | Evaluation Scheme (Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory +Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks - 40 | Marks: 60 |
| Pre-requisites: Basics of Linear Programming Problem, Basics of general mathematics and probability distributions | | | | | |
| Course Objectives: | | | | | |
| <ol style="list-style-type: none"> 1. To understand various methods of linear programming problems, 2. To learn concept of Inventory control, 3. To learn use of Replacement theory, 4. To learn applications of Simulation, Reliability and Survival Analysis. | | | | | |
| Course Outcomes: | | | | | |
| <ol style="list-style-type: none"> 1. Learner will be able to solve problems using algorithms of LPP, 2. Learner will be able to understand use of inventory and replacement in real life situations, 3. Learner will be able to identify situations where Simulation techniques and Survival Analysis can be applied. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <p><u>LINEAR PROGRAMMING PROBLEM</u> Two-Phase Simplex Method, Algorithm. Dual Simplex Method, Algorithm. Post Optimality Sensitivity Analysis. Effect on optimal solution to the LPP and improvement in the solution due to (i) Change in cost coefficient, (ii)Change in the element of requirement vector, (iii) Addition/deletion of a variable,(iv) Addition/deletion of a constraint. (All expressions without proof)</p> <p>Integer programming problem (IPP): Introduction, solution of IPP using (i) Graphical method, (ii) Gomory's Method.</p> | | | | 15 |

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| II | <p><u>INVENTORY CONTROL</u></p> <p>Introduction to Inventory Management.</p> <p><u>Deterministic Models:</u></p> <p>Single item static EOQ models for</p> <p>(i) Constant rate of demand with instantaneous replenishment, with and without shortages.</p> <p>(ii) Constant rate of demand with uniform rate of replenishment, with and without shortages.</p> <p>(iii) Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks.</p> <p><u>Probabilistic models:</u> Single period with</p> <p>(i) Instantaneous demand (discrete and continuous) without setup cost.</p> <p>(ii) Uniform demand (discrete and continuous) without set up cost.</p> | 15 |
| III (a) | <p><u>REPLACEMENT</u></p> <p>Replacement of items that deteriorate with time and value of money (i) remains constant, (ii) changes with time.</p> <p>Replacement of items that fail completely: Individual replacement and Group replacement policies.</p> | 7 |
| III (b) | <p><u>SIMULATION</u></p> <p>Concept and Scope of simulation. Monte Carlo Technique of Simulation. Generation of random numbers using (i) Mid. Square Method and (ii) Multiplicative Congruential Method. Inverse method of generation of random observations from (i) Uniform distribution, (ii) Exponential distribution, (iii) Gamma distribution, (iv) Normal distribution. Simulation techniques applied to inventory and queueing model.</p> | 8 |
| IV | <p><u>RELIABILITY and SURVIVAL ANALYSIS</u></p> <p><u>RELIABILITY:</u></p> <p>Concept of reliability, Hazard-rate. Bathtub 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).</p> <p><u>SURVIVAL ANALYSIS</u></p> <p>Concept of Survival analysis, censoring of data and its types, estimating Median survival time, Kaplan-Meire approach for survival analysis.</p> | 15 |
| | Total | 60 |

Reference Books:

1. Vora N. D. : Quantitative Techniques in Management, Third edition, McGraw Hill Companies.
2. Kantiswaroop, P.K. Gupta, Manmohan: Operations Research, Twelfth edition, Sultan Chand & sons.
3. Sharma S. D. : Operations Research, Eighth edition, Kedarnath Ramnath & Co.
4. Taha Hamdy A. : Operations Research : Eighth edition, Prentice Hall of India Pvt. Ltd.
5. Barlow R. E. and Prochan Frank : Statistical Theory of Reliability and Life Testing Reprint, First edition, Holt, Reinhart and Winston.
6. Mann N. R., Schafer R.E., Singapurwalla N. D.: Methods for Statistical Analysis of Reliability and Life Data. First edition, John Wiley & Sons.
7. Kleinbaum, D. G. and Klein, M. (2012). Survival Analysis: A Self-Learning Text, 3rd Ed, Springer, New York
8. Liu, X. (2012). Survival Analysis: Models and Applications, Wiley, New York
9. Smith, P.J. (2002): Analysis of Failure and Survival data. CRC.
10. H J Vaman, Prabhanjan Tattar: Survival Analysis , First Edition, A Chapman and Hall Book.
11. Narayanaswamy Balkrishna, C. R. Rao: Advances in Survival Analysis, First edition, Elsevier North Holand.

List of Topics for the practicals:

| Title of the Practical | No. of Pract. |
|-----------------------------------|----------------------|
| L.P.P. | 1 |
| Inventory- Deterministic Models | 1 |
| Inventory-Probabilistic Models | 1 |
| Replacement | 1 |
| Simulation (using software) | 1 |
| Reliability and Survival Analysis | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

| | | | | | |
|--|---|--|------------------------------------|---|---------------------------------------|
| Programme: B.Sc. | | | | Semester: VI | |
| Course: Statistics Paper IV (ELEMENTS OF ACTUARIAL SCIENCE) | | | | Course Code: BH. USST604 | |
| Teaching Scheme | | | | Evaluation Scheme (Theory) | |
| Lecture (Periods per week) | Practical (Periods per week per batch) | Tutorial (Periods per week per batch) | Credits (Theory+ Practical) | Continuous Internal Assessment (CIA) | End Semester Examination (ESE) |
| 4 | 4 | -- | 3 + 1 | Marks : 40 | Marks: 60 |
| Pre-requisites: Nil | | | | | |
| Course Objectives: | | | | | |
| 1. To introduce students to basic demographic terms | | | | | |
| 2. To introduce students to basic elementary ideas which provide mathematical basis for elements of actuarial science. | | | | | |
| 3. To introduce students to principles of premium calculations in life assurance plans. | | | | | |
| Course Outcomes: | | | | | |
| 1. Students will be able to calculate survival/death probabilities in various mortality patterns. | | | | | |
| 2. Students will be able to calculate present values and accumulated values in various types of annuities. | | | | | |
| 3. Students will be able to calculate net premiums in various assurance plans. | | | | | |
| Detailed Syllabus: (per session plan) | | | | | |
| Unit | Description | | | | Periods |
| I | <u>MORTALITY TABLES</u> 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 |
| II | <u>COMPOUND INTEREST AND ANNUITIES CERTAIN</u> 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 installments form arithmetic progression (iii) annuity with frequency different from that with which interest is convertible. Redemption of loan. | | | | 15 |

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| III | <u>LIFE ANNUITIES</u> 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 |
| IV | <u>ASSURANCE BENEFITS</u> 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) double endowment assurance (vi) special endowment assurance (vii) deferred temporary assurance. Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Natural and Office premiums. | 15 |
| | Total | 60 |

Reference Books:

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.

List of Topics for the practicals:

| Title of the Practical | No. of Practicals |
|------------------------|-------------------|
| Mortality Tables | 2 |
| Annuities Certain | 2 |
| Life Annuities | 1 |
| Assurance Benefits | 1 |

Details of Conduct of Practical Examination (Evaluation Scheme): At the end of the semester, examination of 2 hours duration and 40 marks shall be held for each course. 10 marks for viva and journal (40+10 =50)

Details of Continuous Internal Assessment (CIA)

For continuous internal assessment, it is proposed to hold one class test (for 20 marks) and one assignment /project/survey conduction & data presentation using data visualization techniques, learnt in a course to be given (for 20 marks) on topics which they may explore on their own (under due guidance by teacher).

Any other information: Batch size of practical batch/Tutorial batch as prescribed by University of Mumbai.

Semester V & VI

| Course | 01 | | | 02 | | | Each 03 & 04 | | | Grand Total |
|------------------|------------|-----------|------------|------------|-----------|------------|--------------|-----------|------------|-------------|
| | Internal | External | Total | Internal | External | Total | Internal | External | Total | |
| Theory | 40 | 60 | 100 | 40 | 60 | 100 | 40 | 60 | 100 | 300 |
| Practical | --- | 50 | 50 | --- | 50 | 50 | --- | 50 | 50 | 150 |

Rubrics of evaluation for ESE

| Unit | Knowledge | Understanding | Analytical & critical thinking | Total marks/unit |
|---------------------|-----------|---------------|--------------------------------|------------------|
| 1 | 04 | 04 | 04 | 12 |
| 2 | 04 | 04 | 04 | 12 |
| 3 | 04 | 04 | 04 | 12 |
| 4 | 04 | 04 | 04 | 12 |
| All units | 04 | 04 | 04 | 12 |
| Total per objective | 20 | 20 | 20 | 60 |
| % weightage | 33.33 | 33.33 | 33.34 | 100 |

Rubrics of evaluation for CIA-2 assignment: Presentation/debate

Class: _____ **Roll No** _____ **Topic** _____

| Parameter s | Max Marks | 80 – 100% Excellent | 60 -80% Good | 40 – 60% Satisfactory | 20 – 40% Poor | 0-20% very poor |
|---|------------------|--------------------------------|-------------------------|----------------------------------|--------------------------|------------------------|
| Content | 10 | | | | | |
| Content: Introduction – | 02 | | | | | |
| Content: Development | 03 | | | | | |
| Content:– Conclusion - | 03 | | | | | |
| Content: - Bibliography | 02 | | | | | |
| Effective communicati on skill | 10 | | | | | |
| Language, Style and Structure; | 05 | | | | | |
| Teaching aids; | 05 | | | | | |
| Total | 20 | | | | | |
| | | | | | | |

Name of evaluator _____

date _____

EXAMINATION PATTERN

FOR ALL THEORY COURSES:

- 40 marks Continuous Internal Assessment (CIA) & 60 marks End Semester Examination (ESE) for a theory course and 100 marks semester end evaluation for a practical course.
- One CIA of 20 marks during a semester with objective type questions/MCQ test using online/offline mode, testing conceptual understanding /analytical and numerical abilities.
- One CIA of 20 marks involving assignments/survey presentation and analysis/ literature review/ book review/project.
- **In case of offline evaluation**, 60 marks and Two-hour duration ESE containing 4/5 compulsory questions of 15/12 marks each with internal options. One descriptive type of question on each unit and one objective type of questions based on all units in the syllabus.
- **In case of online evaluation**, 60 marks and 90 minutes duration ESE containing 3/4 sections (unit wise) each containing 20 marks/15marks MCQs of 1 or 2 marks on each unit in the syllabus. Questions to be framed in such a manner that it would test students' understanding, analytical abilities, and critical thinking.

FOR ALL PRACTICAL COURSES:

- 40 marks and 2 hours evaluation per course based on practical conducted during the semester which will test ability to apply the statistical tools and techniques in practical situations, numerical and analytical abilities of students. Problem solving using statistical packages to be tested wherever feasible. 10 marks per course be allocated to viva/journal /computer laboratory work.

| | |
|---|---|
| 1 | Rational on which revision is done. |
| | Stated above |
| 2 | Rational for M.Sc. Syllabi. |
| | -NA- |
| 3 | What is the new idea you want the student to Learn.? |
| | To give basic idea of a concept in accordance with the topic that is taught in TYBSc. R-software is introduced to the students to gain the knowledge of practical application of theory topics that are learnt in the course. |
| 4 | Which foreign and national syllabi have you checked and what did you include from it ? |
| | We checked syllabi of Harvard University, Pune University, Jalgaon University, Delhi University. Not included any topic from it as our syllabi contains some of the topics from these syllabi. |
| 5 | The change in syllabi that will create new Jobs |
| | Consulting companies like TCS, EY, Accenture etc. uses Software like R which will be beneficial for the students to look for jobs. Data science is completely based on core statistics. Companies like Flipkart, Amazon, Myntra etc. use recommendation systems which are operated on Software like R. |
| 6 | Self-study material |
| | Students can opt for different course on Swayam, Coursera, NPTEL, Udemy etc. Students can refer to websites like NDL, KD nuggets academia etc. for various reference books, research papers and for reading & writing blogs. |