**AC ITEM No. 4.6(c)**

**Shri Vile Parle Kelavani Mandal's**

**[ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE**
**JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)**

***NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),***
***Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,***
***Best College (2016-17), University of Mumbai***

Affiliated to the

# UNIVERSITY OF MUMBAI

## Program: B.Sc.

**Course:** **PROBABILITY, DISTRIBUTION THEORY & ORDERED STATISTICS**
**USMAST501**

## Semester: V

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

# *PREAMBLE*

In the first and second year, the learner has gone through the concepts of Statistics and knows how and when to use the statistical procedures. He is also able understand why these procedures should be used.

In the third year of their study, the learners will be taught advanced concepts of probability theory, some advanced knowledge of distribution theory, Parametric / Statistical inference, testing of hypothesis. They will also be introduced to the concept of stochastic process. In applied statistics they will learn Bio Statistics, Actuarial Science, Reliability, Advanced concepts of Forecasting and Regression Models.

The learners will be encouraged to make use of the knowledge of R software to solve the practicals.

In the Applied Component part, they will study the subject of Elements of Operations Research. The concepts of various Allocation models, Game theory, Information Theory, Queueing Theory, Decision making under certainty, risk, uncertainty and conflict, will be taught to the learners.

The courses are as follows:-

**Semester V** :

USMAST501 : PROBABILITY,DISTRIBUTION THEORY & ORDERED STATISTICS

USMAST 502: STATISTICAL INFERENCE: ESTIMATION THEORY

USMAST 503 : APPLIED STATISTICS 3 (BIOSTATISTICS)

USMAST 504 : APPLIED STATISTICS 4 (ELEMENTS OF ACTURIAL SCIENCE)

USMA ACST5APPLIED COMPONENT: ELEMENTS OF OPERATIONS RESEARCH I

**Semester VI :**

| | |
|---|---|
| USMAST601 : | PROBABILITY GENERATING FUNCTIONS & ELEMENTS OF STOCHASTIC PROCESSES |
| USMAST602 : | STATISTICAL INFERENCE 02: TESTING OF HYPOTHESIS |
| USMAST603: | APPLIED STATISTICS 5: REGRESSION MODELS |
| USMAST604: | APPLIED STATISTICS 6: (Vital Statistics, Simulation, Reliability and Insurance Products) |
| USMAACST6: | APPLIED COMPONENT: ELEMENTS OF OPERATIONS RESEARCH II |

I profusely thank all the ad-hoc committee members for their efforts in drafting the syllabus.

**N.B.- For Main Subject of Statistics:**

(i) The duration of each theory lecture will be of 48 minutes. A course consists of 4 units. For each unit the number of lecture hours allotted are 15. The total number of lecture hours for each course will thus be 60.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 4 lecture hours, i.e. of 192 minutes.
For practical component the value of One Credit is equal to 40 learning hours.

(iii) Thus in a week, a student will study 16 lecture hours of theory and 16 lecture hours of practicals.

N.B.- For the Applied Component: Elements of Operations Research:

(i) The duration of each theory lecture will be of 48 minutes. A course consists of 4 units. For each unit the number of lecture hours allotted are 1. The total number of lecture hours for each course will thus be 4.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 4 lecture hours.
For practical component the value of One Credit is equal to 40 learning hours.

(iii) Thus in a week, a student will study 4 lecture hours of theory and 4 lecture hours of practicals.

## Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

**a) Details of Continuous Assessment (CA)**

25% of the total marks per course:

**Continuous Assessment has to be done in the form of Internal class test of 25 marks**

**b) Details of Semester End Examination**

75% of the total marks per course. Duration of examination will be two and half hours.

| **Question Number** | **Description** | **Marks (with option)** | **Total Marks** |
|---|---|---|---|
| Q1 | Based on Unit 1 | 30 | 15 |
| Q2 | Based on Unit 2 | 30 | 15 |
| Q3 | Based on Unit 3 | 30 | 15 |
| Q4 | Based on Unit 4 | 30 | 15 |
| Q5 | Mixed bag question | 30 | 15 |
| | | **Total Marks** | **75** |

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: V

**Course:** **PROBABILITY, DISTRIBUTION THEORY & ORDERED STATISTICS**

**USMAST501**

**Choice Based Credit System (CBCS) with effect from the Academic year 2018-19**

| **Program: B.Sc . (2018-19 onwards)** | | | | **Semester: V** | |
|---|---|---|---|---|---|
| **Course: PROBABILITY, DISTRIBUTION THEORY & ORDERED STATISTICS** | | | | **Course Code: USMAST501** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5 Theory) + 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1.To introduce the learner to advance concepts in probability.

2. To introduce the learner to advanced concepts of mathematical statistics and discrete distribution theory.

3. The learner will be able to use the concept of MGF to derive moments of discrete distributions. The learner will know the use of Trinomial and Multinomial distributions.

4. The learner will learn the concept of Order statistics, its importance and applications in real life situation.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1:** Compute probability to different probability models.

**CO2:** Use the concept of MGF to derive moments of discrete distributions. The learner will know the use of Trinomial and Multinomial distributions.

**CO3:** Solve different types of problems involving the BVN. The learner learn to test the significance of population correlation coefficient.Also, learn to make use of Fisher's z transformation.

**CO4:** Compute the distributions of the $1^{st}$, $n^{th}$ and $r^{th}$ order statistics and able to apply them to different problems

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Probability | 15 L |
| **2** | Joint Moment Generating Function ,Trinomial & Multinomial Distribution | 15 L |
| **3** | Bivariate Normal distribution | 15L |
| **4** | Order Statistics | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |
| | | |

| | | |
|---|---|---|
| **Unit** | **Topic** | **No. of Hours/Credits** |
| **Module 1** | **Probability** | **12 hrs (15 L)** |
| | Revision of Probability concepts with examples as covered in SEM 1. Sub populations and partitions.<br>Distribution of r balls into n cells.<br>Derivation of<br>a) Ar,n: Number of distinguishable distributions of putting r indistinguishable balls in n cells;<br>b) Number of distinguishable distributions of putting r indistinguishable balls in n cells such that no cell is empty.<br>Ordered samples and Theory of runs. Concept of Occupancy numbers. Probabilities based on<br>(i) Maxwell Boltzmann;<br>(ii) Bose Einstein and<br>(iii) Fermi Dirac Statistics.<br>Theorems on Probability of realization of : (with proofs)<br>(i) At least one;<br>(ii) Exactly m;<br>(iii) At least m of N events Matching and Guessing problems. | |
| **Module 2** | **JOINT MOMENT GENERATING FUNCTION, TRINOMIAL & MULTINOMIAL DISTRIBUTION** | **12 hrs (15 L)** |
| | (i) 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.<br>Concept and definition of Multivariate MGF.<br>(ii)Trinomial distribution:<br>Definition of joint probability distribution of (X,Y). Joint moment generating function, moments □rs where r=0, 1, 2 and s=0, 1, 2.<br>Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between (X, Y).<br>Distribution of the Sum X+Y.<br>(iii) Extension to Multinomial distribution with parameters (n, p1 p2,…..pk-1) where p1+ p2+…pk-1+ pk= 1.<br>Expression for joint MGF.<br>Derivation of: joint probability distribution of (Xi,Xj);<br>Conditional probability distribution of Xi given Xj = xj. | |
| **Module 3** | **BIVARIATE NORMAL DISTRIBUTION (BVN)** | |
| | i) Definition of joint probability distribution (X, Y). Joint Moment Generating function, moments μrs where r=0, 1, 2 | **12 hrs(15 L)** |

| | | |
|---|---|---|
| | and s=0, 1, 2. Marginal & Conditional distributions. Their Means & Variances. Correlation coefficient between the random variables.<br>Necessary and sufficient condition for the independence of X and Y. Distribution of aX + bY, where 'a' and 'b' are constants.<br>ii) Distribution of sample correlation coefficient when $\rho = 0$. To test the significance of a correlation coefficient. Fisher's z transformation.<br>Tests for (i) Ho : $\rho=\rho_0$ (II) Ho: $\rho_1 = \rho_2$ Confidence interval for $\rho_1 - \rho_2$. | |
| **Module4** | Order Statistics | **12hrs(15 L)** |
| | (i) Definition of Order Statistics based on a random sample.<br>(ii) Derivation of:<br>(a) Cumulative distribution function of rth order statistic;<br>(b)Probability density functions of the rth order statistic;<br>(c) Joint Probability density function of the rth and the sth order statistic ( r<s);<br>(d)Joint Probability density function of all n ordered statistics.<br>(iii) Probability density function of Median (in the case of odd sample sizes) and Range for Uniform and Exponential distributions | |

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 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 |

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: V

**Course:** **STATISTICAL INFERENCE I: ESTIMATION THEORY**

**USMAST502**

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | | | | **Semester: V** | |
|---|---|---|---|---|---|
| **Course: STATISTICAL INFERENCE I: ESTIMATION THEORY** | | | | **Course Code: USMAST502** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5 (Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. To introduce the learner to the basic concepts of statistical inference
2. The learner will learn advanced theorems concerning the properties of an estimator.
3. The learner will learn the different methods of point estimation.
4. To make the learner aware of how to make use of prior information for better inference using Bayes' Theorem. Also, learn the concept of confidence interval.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1:** The learner will get to know the terminology used for statistical inference. Also, learn the properties of good estimator and solve different examples involving discrete and continuous probability distributions.

**CO2:** The learner will learn the use of MVUE, CRLB, Fishers information and MVBUE involving the parameters of discrete and continuous probability distributions.

**CO3:** The learner will be able to find the point estimates of parameters for standard discrete and continuous distributions.

**CO4:** Learner will be able to compute point estimates using Bayes' estimation procedure. also be able to compute confidence interval for parameters of standard discrete and continuous distributions

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Point Estimation & Properties of Estimators- I | 15 L |
| **2** | Properties of Estimators- II | 15 L |
| **3** | Methods of Estimation | 15L |
| **4** | Bayesian Estimation and Confidence Interval | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **POINT ESTIMATION AND PROPERTIES OF ESTIMATOR- I** | **12 hrs (15 L)** |
| | Notion of a parameter and parameter space. Problem of Estimation, Definitions of Statistic, Estimator and Estimate.<br>Properties of a good estimator:<br>(a) 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).<br>Proofs of the following results regarding unbiased estimators.<br>(i) Two distinct unbiased estimators of □(θ) give rise to infinitely many unbiased estimators.<br>(ii) If T is an unbiased estimator of θ, then □(T) is unbiased estimator of □(θ) provided □(.) is a linear function.<br>(b) Consistency: Definition, Proof of the following theorem:<br>An estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity.<br>(c) Sufficiency: Concept and definition of Sufficiency, Neymann Factorization Theorem (without proof). Exponential family of probability distributions and Sufficient statistic.<br>(d) Relative efficiency of an estimator. Illustrative examples | |
| **Module 2** | **PROPERTIES OF ESTIMATOR- II** | **12 hrs (15 L)** |
| | Minimum variance unbiased estimator (MVUE), Uniqueness property of MVUE. Fisher information function.<br>Statement and proof of Cramer-Rao inequality, Cramer–Rao Lower Bound (CRLB).<br>Definition of minimum variance bound unbiased estimator (MVBUE) of □(θ).Definition of Efficient estimator using CRLB. | |
| **Module 3** | **METHODS OF ESTIMATION** | **12 hrs(15 L)** |
| | 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.<br>Distinction between likelihood function and joint p.d.f. / p.m.f.<br>Derivation of Maximum Likelihood Estimator (M.L.E.) for parameters of standard distributions (case of one and two unknown parameters).<br>Properties of M.L.E(without proof)<br><br>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. | |

| **Module4** | **BAYESIAN ESTIMATION AND CONFIDENCE INTERVAL** | **12hrs(15 L)** |
|---|---|---|
| | Bayesian Estimation:<br>Prior distribution, Posterior distribution, Loss function, Risk function, Bayes' solution under Squared Error Loss Function (SELF) and Absolute Error Loss function.<br>Interval Estimation:<br>Concept of Confidence Interval and Confidence Limits.<br>Definition of pivotal quantity and its use in obtaining confidence limits. Derivation of 100(1-α)% equal tailed confidence interval for the parameters μ,<br>μ1-μ2. (Population variance(s) known / unknown),$\square^2$,$\square_1^2$,$\square_2^2$.(Normal distribution).<br>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 $\square$ based on the random sample from Uniform distribution $(0,\square)$ by using distribution of M.L.E. | |

| **Course** | PRACTICALS-1 | Credits | L / Week |
|---|---|---|---|
| USMASTP512 | Practicals of Course USMAST501+USMAST502 | 3 | 8 |

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 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 (1989 ) | New Mathematical Statistics | SatyaPrakashan, New Market, New Delhi,5 |
| 9. | Pawagi V.R.& Ranade Saroj A. | Statistical Methods Using R Software | Nirali Publications |

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: V

## Course: APPLIED STATISTICS 3 (BIOSTATISTICS

## USMAST503

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | | | | | **Semester: V** |
|---|---|---|---|---|---|
| **Course: APPLIED STATISTICS 3 (BIOSTATISTICS)** | | | | | **Course Code: USMAST503** |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5(Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1.To introduce the learner to epidemic models.
2. To introduce learner to different types of assays.
3. To introduce learner to clinical trials
4. To introduce learner to concepts of Bioequivalence.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1**: The learner will able to estimate the value of 'p' for different epidemic model.

**CO2**: Learner will learn to estimate the potencies for different assays, compute confidence interval using Fieller's theorem and perform ANOVA for different assays.

**CO3**: The learner will know when and how to perform clinical trial.

**CO4**: Learner will learn to estimate PK parameters using 'time vs. concentration' profiles. Also, learn to establish Bioequivalence of generic drugs.

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Epidemic Models | 15 L |
| **2** | Bioassays | 15 L |
| **3** | Clinical Trials | 15L |
| **4** | Bioequivalence | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **EPIDEMIC MODELS** | **12 hrs (15 L)** |
| | 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, its asymptotic variance for households of sizes up to 4. | |
| **Module 2** | **BIOASSAYS** | **12 hrs (15 L)** |
| | Meaning and scope of bioassays. Relative potency. Direct assays. Fieller's theorem. ii) 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. | |
| **Module 3** | **CLINICAL TRIALS: AN INTRODUCTION** | **12 hrs(15 L)** |
| | 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. | |
| **Module4** | **BIOEQUIVALENCE** | **12hrs(15 L)** |
| | Definitions of Generic Drug product. Bioavailability, Bioequivalence, Pharmakokinetic (PK) parameters Cmax, AUCt, AUC0-∞, Tmax, Kel, Thalf. 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). | |

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 1. | Bailey N.T.J. | The Mathematical theory of infectious diseases, Second edition | Charles Griffin and Co. London |
| 2. | Das M.N and GiriN.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 |

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: V

**Course:** **APPLIED STATISTICS 4 (ELEMENTS OF ACTURIAL SCIENCE)**

**USMAST504**

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | | | | | **Semester: V** |
|---|---|---|---|---|---|
| **Course: APPLIED STATISTICS 4 (ELEMENTS OF ACTURIAL SCIENCE)** | | | | | **Course Code: USMAST504** |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5(Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. Learner will review elements of ordinary life tables that are essential to understand mortality experience of population and information about life expectation
2. To make learner aware of the use of compounding for calculating different types of annuities.
3. To define Life Annuities and describe its purpose and principles
4. To provide an overview of the development of the life assurance market necessary to understand current practice. It provides an overview of key components of life assurance.

**Course Outcomes:**

After completion of the course,

**CO1:** Learner will able to compute and interpret various mortality functions.

**CO2:**The learner will be able to calculate the present and accumulated values for different types of annuities and also to compute the EMI's for loans.

**CO3**: The learner will be able to describe and understand the various types of life annuities.

**CO4**:The learner will obtain the knowledge of life products and hence will be able to distinguish between different types of assurance policies

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Mortality Tables | 15 L |
| **2** | Compound Interest And Annuities Certain | 15 L |
| **3** | Life Annuities | 15L |
| **4** | Assurance Benefits | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **MORTALITY TABLES** | **12 hrs (15 L)** |
| | Various mortality functions. Probabilities of living and dying. The force | |

| | | |
|---|---|---|
| | of mortality. Estimation of μx from the mortality table. Central Mortality Rate. Laws of mortality: Gompers's and Make ham's first law. Select, Ultimate and Aggregate mortality tables.<br>Stationary population. Expectation of life and Average life at death. | |
| **Module 2** | **COMPOUND INTEREST AND ANNUITIES CERTAIN** | **12 hrs (15 L)** |
| | 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.<br>Present and accumulated values of:<br>(i) increasing annuity;<br>(ii)increasing annuity when successive installments form arithmetic progression;<br>(iii) annuity with Frequency different from that with which interest is convertible. Redemption of loan. | |
| **Module 3** | **LIFE ANNUITIES** | **12 hrs(15 L)** |
| | 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). | |
| **Module4** | **ASSURANCE BENEFITS** | **12hrs(15 L)** |
| | Present value of Assurance benefits in terms of commutation functions of :<br>(i) pure endowment assurance;<br>(ii) temporary assurance;<br>(iii) endowment assurance;<br>(iv) whole life assurance;<br>(v) special endowment assurance;<br>(vi) deferred temporary assurance.<br>Net premiums: Net level annual premiums (including limited period of payment) for various assurance plans. Office premiums | |

| **Course** | PRACTICALS-2 | Credits | L / Week |
|---|---|---|---|
| USMASTP534 | Practicals of Course USMAST503+USMAST504 | 3 | 8 |

**Suggested reading:**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 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 |

**AC ITEM No. 4.6(c)**

**Shri Vile Parle Kelavani Mandal's**

**[ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE**

**JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)**

***NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),***

***Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,***

***Best College (2016-17), University of Mumbai***

Affiliated to the

# UNIVERSITY OF MUMBAI

## Program: T.Y.B.Sc. (USMAACST5)

## Course: APPLIED COMPONENT

## ELEMENTS OF OPERATIONS RESEARCH

## Semester: V

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

**SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)**

## Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

**a) Details of Continuous Assessment (CA)**

25% of the total marks per course:

| Continuous Assessment | Details | Marks |
|---|---|---|
| **Component 1 (CA-1)** | Test | 15 marks |
| **Component 2 (CA-2)** | Test | 10 marks |

**b) Details of Semester End Examination**

75% of the total marks per course. Duration of examination will be two and half hours.

| Question Number | Description | Marks (with option) | Total Marks |
|---|---|---|---|
| Q1 | Based on Unit 1 | 30 | 15 |
| Q2 | Based on Unit 2 | 30 | 15 |
| Q3 | Based on Unit 3 | 30 | 15 |
| Q4 | Based on Unit 4 | 30 | 15 |
| Q5 | Mixed bag question | 30 | 15 |
| | | **Total Marks** | **75** |

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

**SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)**

| **Program: B.Sc . (2018-19)** | | | | **Semester: V** | |
|---|---|---|---|---|---|
| **Course: APPLIED COMPONENT (ELEMENTS OF OPERATIONS RESEARCH I)** | | | | **Course Code: USMAACST5** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Lectures per week)** | **Practical (Lectures per week)** | **Tutorial (Lectures per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 | 4 | | 3 | 25 | 75 |

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Linear Programming Problem | 15 L |
| **2** | Integer Programming Problem , Sensitivity analysis | 15 L |
| **3** | Transportation Problem, Assignment Problem, Sequencing | 15L |
| **4** | Decision Theory | 15L |
| | **Total** | **60 L** |
| **Practicals** | | **60 L** |

| **Module** | **Description** | **No of Lectures** |
|---|---|---|
| **1** | **<u>Linear Programming Problem (L.P.P.):</u>**<br>Mathematical Formulation: Maximization & Minimization. Concepts of Solution, Feasible Solution, Basic Feasible Solution, Optimal solution. Graphical Solution for problems with two variables.<br>Simplex method of solving problems with two or more variables. Big M method. Solution of LPP for unrestricted variables<br>Concept of Duality. Its use in solving L.P.P. Relationship between optimum solutions to Primal and Dual. Dual simplex algorithm.<br>Economic interpretation of Dual. | 15 |
| **2** | **<u>Integer programming problem (IPP):</u>**<br>Introduction, solution of IPP using<br>1. Graphical method<br>2. Gomory's Method.<br><br>**<u>Sensitivity analysis:-[WITHOUT PROOF]:</u>**<br>1) Variation in the price vector "c".<br>2) Variation in requirement vector "b".<br>3) Addition of a new variable to the LPP | 15 |
| **3** | **<u>Transportation Problem:</u>**<br>Concept, Mathematical Formulation. Concepts of Solution, Feasible Solution. Initial Basic Feasible Solution by North-West Corner Rule, Matrix Minima Method, | 15 |

| | | |
|---|---|---|
| | Vogel's Approximation Method. Optimal Solution by MODI Method. Optimality test, Improvement procedure. Variants in Transportation Problem: Unbalanced, Maximization type.<br><br>**Assignment Problem:**<br>Concept. Mathematical Formulation Solution by: Complete Enumeration Method and Hungarian method. Variants in Assignment Problem: Unbalanced, Maximization type. Travelling Salesman Problem<br><br>**Sequencing :**<br>Processing n Jobs through 2 Machines;<br>Processing n Jobs through 3 Machines;<br>Processing 2 Jobs through m Machines | |
| **4** | **Decision Theory:**<br>Decision making under uncertainty:<br>Laplace criterion, Maximax (Minimin) criterion, Maximin (Minimax) criterion, Hurwicz α criterion, Minimax Regret criterion.<br>Decision making under risk: Expected Monetary Value criterion, Expected Opportunity Loss criterion, EPPI, EVPI.<br>Bayesian Decision rule for Posterior analysis.<br>Decision tree analysis along with Posterior probabilities. | 15 |
| | **Total** | **60** |
| **PRACTICALS** | | **60** |

## PRACTICALS

1. L.P.P I
2. L.P.P II
3. DUALITY AND DUAL SIMPLEX
4. INTEGER PROGRAMMING
5. TRANSPORTATION PROBLEM
6. ASSIGNMENT PROBLEM
7. SEQUENCING
8. DECISION THEORY -I
9. DECISION THEORY -II

**Suggested Readings**


| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 1. | Taha Hamdy A. | Operations Research : Eighth edition | Prentice Hall of India Pvt. Ltd |
| 2. | Operations Research | H. A.Taha., 6th edition | Prentice Hall of India |
| 3. | J.K.Sharma, (2001) | Quantitative Techniques For Managerial Decisions | MacMillan India Ltd. |
| 4. | J K Sharma, (1989) | Mathematical Models in Operations Research | Tata McGraw Hill Publishing Company Ltd. |
| 5. | S.D.Sharma | Operations Research, 11th edition | KedarNath Ram Nath& Company |
| 6. | Kantiswaroop and Manmohan, Gupta | Operations Research, 12thEdition | S Chand & Sons |
| 7. | Richard Bronson | Schaum Series book in O.R., 2nd edition | Tata Mcgraw Hill Publishing Company Ltd. |
| 8. | Maurice Sasieni, Arthur Yaspan and Lawrence Friedman,(1959) | Operations Research: Methods and Problems | John Wiley & Sons. |
| 9 | Vora N. D. | Quantitative Techniques in Management, Third edition | McGraw Hill Companies |
| 10 | Bannerjee B. | Operation Research Techniques for Management, First edition | Business Books |

AC ITEM No. 4.6(c)

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**IITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)**

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***Best College(2016-17), University of Mumbai***

Affiliated to the

# UNIVERSITY OF MUMBAI

## Program: T.Y.B.Sc.(USMAST6)

## Course: STATISTICS

## Semester :VI

## Credit Based Semester and Grading System (CBCS) with effect from the academic year 2018-19

# *PREAMBLE*

In the first and second year, the learner has gone through the concepts of Statisticis and knows how and when to use the statistical procedures. He is also able understand why these procedures should be used.

In the third year of their study, the learners will be taught advanced concepts of probability theory, some advanced knowledge of distribution theory, Parametric / Statistical inference, testing of hypothesis. They will also be introduced to the concept of stochastic process. In applied statistics they will learn Bio Statistics, Actuarial Science, Reliability, Advanced concepts of Forecasting and Regression Models.

The learners will be encouraged to make use of the knowledge of R software to solve the practicals.

In the Applied Component part, they will study the subject of Elements of Operations Research. The concepts of various Allocation models, Game theory, Information Theory, Queueing Theory, Decision making under certainty, risk, uncertainty and conflict, will be taught to the learners.

The courses are as follows:- Semester V :

USMAST501 : PROBABILITY,DISTRIBUTION THEORY & ORDERED STATISTICS
USMAST 502: STATISTICAL INFERENCE: ESTIMATION THEORY
USMAST 503 : APPLIED STATISTICS 3 (BIOSTATISTICS)
USMAST 504 : APPLIED STATISTICS 4 (ELEMENTS OF ACTURIAL SCIENCE)
USMA ACST5APPLIED COMPONENT: ELEMENTS OF OPERATIONS RESEARCH I

Semester VI :

USMAST601 : PROBABILITY GENERATING FUNCTIONS & ELEMENTS OF STOCHASTIC PROCESSES
USMAST602 : STATISTICAL INFERENCE 02: TESTING OF HYPOTHESIS
USMAST603: APPLIED STATISTICS 5: REGRESSION MODELS
USMAST604: APPLIED STATISTICS 6: (Vital Statistics, Simulation, Reliability and Insurance Products)
USMA ACST6: APPLIED COMPONENT: ELEMENTS OF OPERATIONS RESEARCH II

I profusely thank all the ad-hoc committee members for their efforts in drafting the syllabus.

**N.B.- For Main Subject of Statistics:**

(i) The duration of each theory lecture will be of 48 minutes. A course consists of 4 units. For each unit the number of lecture hours allotted are 15. The total number of lecture

hours for each course will thus be 60.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 4 lecture hours, i.e. of 192 minutes.
For practical component the value of One Credit is equal to 40 learning hours.

(iii) Thus in a week, a student will study 16 lecture hours of theory and 16 lecture hours of practicals.

N.B.- For the Applied Component: Elements of Operations Research:

(i) The duration of each theory lecture will be of 48 minutes. A course consists of 4 units. For each unit the number of lecture hours allotted are 1. The total number of lecture hours for each course will thus be 4.

(ii) There will be one practical per batch for each course. The duration of each practical will be of 4 lecture hours.
For practical component the value of One Credit is equal to 40 learning hours.

(iii) Thus in a week, a student will study 4 lecture hours of theory and 4 lecture hours of practicals.

## Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

**a) Details of Continuous Assessment (CA)**

25% of the total marks per course:

**Continuous Assessment has to be done in the form of Internal class test of 25 marks**

**b) Details of Semester End Examination**

75% of the total marks per course. Duration of examination will be two and half hours.

| **Question Number** | **Description** | **Marks (with option)** | **Total Marks** |
|---|---|---|---|
| Q1 | Based on Unit 1 | 30 | 15 |
| Q2 | Based on Unit 2 | 30 | 15 |
| Q3 | Based on Unit 3 | 30 | 15 |
| Q4 | Based on Unit 4 | 30 | 15 |
| Q5 | Mixed bag question | 30 | 15 |
| | | **Total Marks** | **75** |

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

AC ITEM No. 4.6(c)

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: VI

## Course: PROBABILITY GENERATING FUNCTIONS & ELEMENTS OF STOCHASTIC PROCESSES

## USMAST601

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | **Semester: VI** |
|---|---|
| **Course: PROBABILITY GENERATING FUNCTIONS & ELEMENTS OF STOCHASTIC PROCESSES** | **Course Code: USMAST601** |

| **Teaching Scheme** | | | | **Evaluation Scheme** | |
|---|---|---|---|---|---|
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5(Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. To introduce the learner to the concepts of PGF.
2. Introduce learner to stochastic process with knowledge about the random variable and random process.
3. Learner will learn to model the stochastic processes.
4. To develop the idea that processes evolving randomly in time can be modeled mathematically in terms of sequences or families of dependent random variables.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1:** Learner will able to find PGF's of different discrete probability distributions. Also, will able to use the knowledge of PGF to compute probabilities for different problems.

**CO2:** Learner will get knowledge of stochastic processes and their applications.

**CO3:** Compute the distributions of the $1^{st}$, $n^{th}$ and $r^{th}$ order statistics and able to apply them to different problems .

**CO4:** On successful completion of the course learner will have a good grasp of basic concepts, techniques and results associated with the elementary theory of Markov processes

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Probability Generating Functions | 15 L |
| **2** | Stochastic Processes 1 | 15 L |
| **3** | Stochastic Processes 2 | 15L |
| **4** | Introduction to Markov chains | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |
| | | |
| | | |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **PROBABILITY GENERATING FUNCTIONS** | **12 hrs (15 L)** |
| | Definitions of generating function and probability generating function. Expression for mean and variance in terms of generating functions. Definition of 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.<br>Examples of probability generating functions. | |
| **Module 2** | **Introduction to Stochastic Processes** | **12 hrs (15 L)** |
| | Definition and examples of stochastic process: Classification of general stochastic processes into discrete/continuous time, discrete/continuous state spaces, types of stochastic processes elementary problems, random walk, gambler's ruin problem. | |
| **Module 3** | **Stochastic Processes 2** | |
| | Continuous time Markov Chain: Poisson process and related inter-arrival time distribution Postulates and difference differential equations for :<br>(i) Pure birth process;<br>(ii) Poisson process with initially 'a' members, for a =0 and a >0;<br>(iii) Yule Furry process;<br>(iv) Pure death process;<br>(v) Death process with $\mu_n=\mu$;<br>(vi) Death process with $\mu_n=n\mu$;<br>(vii) Birth and Death process;<br>(viii) Linear growth model.<br>Derivation of $P_n(t)$, mean and variance where ever applicable | **12 hrs(15 L)** |
| **Module4** | **Introduction to Markov chains** | **12hrs(15 L)** |
| | Markov chains: Definition and examples of Markov chain, | |

| | | |
|---|---|---|
| | transition probability matrix, classification of states, recurrence, simple problems, basic limit theorem of Markov Chain (statement only):, stationary probability distribution, applications.<br>Branching process: Definition and examples of discrete time branching process,<br>probability generating function, mean and variance, Probability of extinction problems. | |

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 1. | Feller W | An introduction to probability theory and it's applications, Volume: 1, Third edition | Wiley Eastern Limited |
| 2. | Hogg R. V. & Craig A.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 |
| 10. | Karlin S. and Taylor H.M. (1995) | A First Course in Stochastic Process | Academic Press |

| | | | |
|---|---|---|---|
| 11. | Hoel P.G., Port S.C. and Stone C.J. (1991) | Introduction to Stochastic Process, | Universal Book Stall |
| 12. | Ross S.M. (1983) | Stochastic Process | John Wiley |
| 13. | Taylor H.M. and Karlin S. (1999) | Stochastic Modeling | Academic Press |
| 14. | Parzen E. (1962) | Stochastic Process | Holden-Day |
| 15. | Cinlar E. (1975) | Introduction to Stochastic Processes | Prentice Hall |
| 16. | Adke S.R. and Manjunath S.M. (1984) | An Introduction to Finite Markov Processes | Wiley Eastern |
| 17. | S.D.Sharma | Operations Research, 11th edition | KedarNath Ram Nath& Company |

AC ITEM No. 4.6(c)

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# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: VI

## Course: STATISTICAL INFERENCE II: TESTING OF HYPOTHESIS

## USMAST602

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | | | | **Semester: VI** | |
|---|---|---|---|---|---|
| **Course: STATISTICAL INFERENCE II: TESTING OF HYPOTHESIS** | | | | **Course Code: USMAST602** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5(Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. The learner will learn different terms used in testing of hypothesis and its calculations. Also, testing procedure of simple null hypothesis against simple alternative hypothesis.

2. The learner will learn derivation of test for testing simple hypothesis against simple composite hypothesis without fixed sample size

3. The learner will learn derivation of test for testing simple hypothesis against simple composite hypothesis without fixed sample size.

4. The learner will learn commonly used Nonparametric Test Procedures. Also, will learn advantages and dis advantages of non-parametric testing procedures.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1:**The learner will be able to derive best test for testing simple null hypothesis against simple alternative hypothesis.

**CO2:** The learner will be able to derive best test for testing simple or null hypothesis against composite alternative hypothesis.

**CO3:** The learner will able to derive test for testing simple hypothesis against simple composite hypothesis without fixed sample size and will able to compare it with usual test with fixed sample size.

**CO4:** The learner will able to understand various methods of non-parametric tests and concepts related to the testing of hypothesis. Also, able to Obtain the theoretical and practical knowledge on the analysis of non-parametric.

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Testing of Hypothesis & Most Powerful Tests | 15 L |
| **2** | Uniformly Most Powerful & Likelihood Ratio Tests | 15 L |
| **3** | Sequential Probability Ratio Test | 15L |
| **4** | Non-Parametric Tests | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|

| | | |
|---|---|---|
| **Module 1** | MOST POWERFUL TESTS | **12 hrs (15 L)** |
| | Problem of testing of hypothesis. Definitions and illustrations of<br>(i) Simple hypothesis; (ii) Composite hypothesis;<br>(iii) Null Hypothesis; (iv) Alternative Hypothesis;<br>(v) Test of hypothesis; (vi) Critical region;<br>(vii) Type I and Type II errors; (viii) Level of significance;<br>(ix) size of the test; (x) Power of the test;<br>(xi) Power function of a test; (xii) Power curve;<br>(xiii) p-value;<br>Definition of most powerful test of size $\alpha$ for a simple hypothesis against a simple alternative hypothesis.<br>Neyman-Pearson fundamental lemma. | |
| **Module 2** | UNIFORMLY MOST POWERFUL & LIKELIHOOD RATIO TESTS | **12 hrs (15 L)** |
| | Definition, Existence and Construction of uniformly most powerful (UMP) test. Likelihood ratio principle. Definition of test statistic and its asymptotic distribution (statement only).<br>Construction of LRT for the mean of normal distribution for<br>(i) known $\sigma^2$;(ii) unknown $\sigma^2$ (two sided alternatives).<br>LRT for variance of normal distribution for (i) known $\mu$; (ii) unknown $\mu$ (two sided alternatives hypotheses). | |
| **Module 3** | **SEQUENTIAL PROBABILITY RATIO TEST (SPRT)** | **12 hrs(15 L)** |
| | 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 (a, ß). Problems based on Bernoulli, Binomial, Poisson, Normal, Exponential distributions. Graphical /tabular procedure for carrying out the tests. OC, ASN, ATI. | |
| **Module4** | **NON-PARAMETRIC TESTS** | **12hrs(15 L)** |
| | Need for non-parametric tests.<br>Distinction between a parametric and a non-parametric test.<br>Concept of a distribution free statistic.<br>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.<br>Assumptions, justification of the test procedure for small & large samples. | |

| Course | PRACTICAL-1 | Credits | L / Week |
|---|---|---|---|

| | | | |
|---|---|---|---|
| USMASTP612 | Practicals based on the Course USMAST601+USMAST602 | 3 | 8 |

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 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 Arora and BansiLal | New Mathematical Statistics | SatyaPrakashan, New Market, New |

**AC ITEM No. 4.6(c)**

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# UNIVERSITY OF MUMBAI

**Program: B.Sc.**

**Semester: VI**

**Course:** **APPLIED STATISTICS 5: REGRESSION MODELS**
**USMAST603**

**Choice Based Credit System (CBCS) with effect from the Academic year 2018-19**

| **Program: B.Sc . (2018-19 onwards)** | | | | **Semester: VI** | |
|---|---|---|---|---|---|
| **Course: APPLIED STATISTICS 5: REGRESSION MODELS** | | | | **Course Code: USMAST603** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5(Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. To make the learner aware of Full rank model and least square estimation to estimate parameters.
2.. The learner will learn the concept of multiple and partial correlation coefficients. Also, will learn concept of multiple regression.
3. Calculate the simple linear regression equation for a set of data and know the basic assumptions behind regression analysis. Calculate and interpret the correlation between two variables Determine whether the correlation is significant. Determine whether a regression model is significant. Recognize regression analysis applications for purposes of description and prediction. Calculate and interpret confidence intervals for the regression analysis Recognize some potential problems if regression analysis is used incorrectly.

The learner will learn the basic concepts of time series.

**Course Outcomes:**

After completion of the course, learners would be able to:

**CO1**: Student will able to transform data in the form of full rank model and will find estimate of parameter

**CO2**: The learner will able to compute multiple and partial correlation coefficient and also able to will able to fit regression planes by the method of least squares.

**CO3**: Learner will gain knowledge of:

- Interpretation of linear regression models
- Relationship between correlation and linear regression
- Regression coefficients
- Interpretation of interaction terms
- The assumptions of linear regression analyses, identify violation of the assumptions and learn possible remedies for the violations

**CO4**: The learner will understand the need of time series and its real life examples. Also able to perform calculations of Simple Exponential Smoothing, Double Exponential Smoothing

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | General Linear Hypothesis Model | 15 L |
| **2** | Multiple and Partial Regression | 15 L |
| **3** | Regression Analysis | 15L |
| **4** | Time Series Forecasting techniques | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **General Linear Hypothesis Model** | **12 hrs (15 L)** |
| | Full rank model. $Y = X\beta + \varepsilon$, $\varepsilon \sim N(0,\sigma^2 I)$<br>Derivation of the least square estimates of β, its expectation and variance.<br>Gauss Markoff's theorem for full rank model $Y = X\beta + \varepsilon$, with $E(\varepsilon) = 0$ and $V(\varepsilon) = \sigma^2 I_n$.<br>Derivation of estimator of linear function of parameters $l'\beta$, its expectation and variance and confidence interval. | |
| **Module 2** | **MULTIPLE AND PARTIAL REGRESSION** | **12 hrs (15 L)** |
| | Notion of multiple linear regression. Interpretation of Partial regression coefficients. Yule's notation (trivariate case) Fitting of regression planes by the method of least squares. Variance of the residual term. Definiation and properties of Multiple and partial coreelation coefficients.<br>Expressions in terms of the co- factors of the correlation matrix.<br>Testing the significance of multiple and partial correlation coefficients. | |
| **Module 3** | **Regression Analysis** | **12 hrs(15 L)** |
| | 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 R2 and adjusted R2. Procedure of testing :<br>(i) overall significance of the model<br>(ii) significance of individual coefficients<br>(iii) Significance of incremental contribution of explanatory variable for two explanatory variables model.<br>Confidence intervals for the regression coefficients.<br>Autocorrelation: Concept, Detection using Durbin Watson Test, Generalized Least Square (GLS) method.<br>Heteroscedasticity: Concept, Detection using Breusch-Pagan-Godfrey test. Weighted Least Square (WLS) estimators<br>Multicollinearity: Concept, Detection using (i) R2 & t ratios (ii) Variance Inflation Factor (VIF) | |

| | | |
|---|---|---|
| **Module4** | **Time Series Forecasting** | **12hrs(15 L)** |
| | Time Series regression, Multiplicative Decomposition, Simple Exponential Smoothing, Double Exponential Smoothing (Holt-Winter's model, Introduction to Box Jenkins Models | |

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 1. | Anant Kshirsagar | A course in linear model | marcel Dekker Inc |
| 2. | Donald C. Weber,JohnH. Skillings (1999) | A first course in Design of Experiment A linear model approach | Taylor & Francis |
| 3. | Gupta S.C. and Kapoor V.K. | Fundamentals of Mathematical Statistics, Tenth edition | New Delhi S. Chand & Company Ltd |
| 4. | Damodar Gujrathi, Sangetha S | Basic Econometrics, Fourth edition | McGraw-Hill Companies |
| 5. | Greene William | Econometric Analysis, First edition | McMillan Publishing Company |
| 7. | W. Hardin ,Joseph M. Hilbe | Generalized Linear Models and Extensions Fourth Edition | James |

**AC ITEM No. 4.6(c)**

**Shri Vile Parle Kelavani Mandal's**

**[ITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBE**

**JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)**

***NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),***

***Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,***

***Best College (2016-17), University of Mumbai***

Affiliated to the

# UNIVERSITY OF MUMBAI

## Program: B.Sc.

## Semester: VI

## Course: APPLIED STATISTICS 6: (Vital Statistics, Simulation, Reliability and Insurance Products)

## USMAST604

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

| **Program: B.Sc . (2018-19 onwards)** | | | | **Semester: VI** | |
|---|---|---|---|---|---|
| **Course: APPLIED STATISTICS 6: (Vital Statistics, Simulation, Reliability and Insurance Products)** | | | | **Course Code: USMAST604** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Hours per week)** | **Practical (Hours per week)** | **Tutorial (Hours per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 (3.2 hrs) | 4 (3.2 hrs) | - | 2.5 (Theory)+ 1.5(practical) | 25 | 75 |

**Learning Objectives:**

1. The learner will learn various measures of Mortality, Fertility.
2. The learner will learn the concept of reliability, hazard function and its derivation for standard distributions. Also derivation of reliability of series and parallel systems.
3. To make the learner aware of necessity of simulation in real life and its applications. Also learn Monte Carlo Technique of Simulation.
4. The learner will learn the various available products on insurance.

**Course Outcomes:**

After completion of the course,

**CO1:** Learner will able to perform calculations of various measures of Mortality, Fertility.

**CO2:** The learner will able to compute reliability, hazard function for standard distributions. Also reliability of series and parallel systems.

**CO3**: The learner will be able to generate random sample from various standard distributions. Also, will able to use Monte Carlo Technique of Simulation in real examples.

**CO4**: Learner will get knowledge of health insurances and pension products, which they can apply in their real life.

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Vital Statistics | 15 L |
| **2** | Simulation | 15 L |
| **3** | Reliability | 15L |
| **4** | Insurance Products | 15L |
| | **Total** | **60 L** |
| **PRACTICALS** | | **4 L / Week** |
| | | |

| Unit | Topic | No. of Hours/Credits |
|---|---|---|
| **Module 1** | **Vital Statistics** | **12 hrs (15 L)** |
| | Introduction, Measures of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Age specific death rate, Infant Mortality Rate (IMR) and Standardized Death Rates.<br>Adjusted Measures of Mortality: Direct and Indirect methods, Equivalent Average Death rate, Average of relative death rate, Comparative Mortality index, Life table Death rate. Measurement of Fertility: Crude birth rate, General fertility rate, Age specific fertility rate & Total fertility rate. Gross & Net Reproduction rates. Population growth. Stable and Stationary populations. Concept and determination of rate of increase in stable population. Logistic curve for Population growth. | |
| **Module 2** | **SIMULATION** | **12 hrs (15 L)** |
| | 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. | |
| **Module 3** | **RELIABILITY** | **12 hrs(15 L)** |
| | 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). | |
| **Module4** | **INSURANCE PRODUCTS** | **12hrs(15 L)** |
| | Health insurances<br>• Individual and group mediclaim policy<br>• New changes in mediclaim policy<br>• Cancer insurance Pension product:<br>• Need for retirement planning<br>• Measuring needs<br>• Pension schemes in India<br>• Investing your savings | |
| | | |

| Course | PRACTICALS-2 | Credits |
|---|---|---|
| USM ASTP 634 | Practical-2<br>Based on courseUSMAST603+USMAST604 | 3 |
| | | |

**Suggested reading**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 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. | Vora N. 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 |

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Affiliated to the

# UNIVERSITY OF MUMBAI

## Program: T.Y.B.Sc. (USMAACST6)

## Course: APPLIED COMPONENT

## ELEMENTS OF OPERATIONS RESEARCH

## Semester: VI

## Choice Based Credit System (CBCS) with effect from the Academic year 2018-19

**SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)**

## Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

**a) Details of Continuous Assessment (CA)**

25% of the total marks per course:

| Continuous Assessment | Details | Marks |
|---|---|---|
| **Component 1 (CA-1)** | Test | 15 marks |
| **Component 2 (CA-2)** | Test | 10 marks |

**b) Details of Semester End Examination**

75% of the total marks per course. Duration of examination will be two and half hours.

| Question Number | Description | Marks (with option) | Total Marks |
|---|---|---|---|
| Q1 | Based on Unit 1 | 30 | 15 |
| Q2 | Based on Unit 2 | 30 | 15 |
| Q3 | Based on Unit 3 | 30 | 15 |
| Q4 | Based on Unit 4 | 30 | 15 |
| Q5 | Mixed bag question | 30 | 15 |
| | | **Total Marks** | **75** |

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

**SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)**

| **Program: B.Sc . (2018-19)** | | | | **Semester: VI** | |
|---|---|---|---|---|---|
| **Course: APPLIED COMPONENT (ELEMENTS OF OPERATIONS RESEARCH II)** | | | | **Course Code: USMAACST6** | |
| **Teaching Scheme** | | | | **Evaluation Scheme** | |
| **Lecture (Lectures per week)** | **Practical (Lectures per week)** | **Tutorial (Lectures per week)** | **Credit** | **Continuous Assessment (CA) (Marks - 25)** | **Semester End Examinations (SEE) (Marks- 75 in Question Paper)** |
| 4 | 4 | | 3 | 25 | 75 |

**Outline of Syllabus: (per session plan)**

| **Module** | **Description** | **No of Hours** |
|---|---|---|
| **1** | Inventory Control | 15 L |
| **2** | Replacement | 15 L |
| **3** | Information Theory | 15L |
| **4** | Queueing Theory | 15L |
| | **Total** | 60 L |
| **PRACTICALS** | | 60 L |

| **Module** | **Description** | **No of Lectures** |
|---|---|---|
| **1** | **<u>INVENTORY CONTROL:</u>**<br>Introduction to Inventory Problem Deterministic Models: Single item static EOQ models for:<br>a) Constant rate of demand with instantaneous replenishment, with and without shortages.<br>b) Constant rate of demand with uniform rate of replenishment, with and without shortages.<br>c) Constant rate of demand with instantaneous replenishment without shortages, with at most two price breaks.<br>d) Probabilistic models: Single period with<br>(i) Instantaneous demand (discrete and continuous) without setup cost.<br>(ii) Uniform demand (discrete and continuous) without set up cost. EOQ models with one/two price breaks. | 15/12 hours |
| **2** | **<u>Replacement:</u>**<br>Replacement of items that deteriorate with time and value of money<br>i) remains constant;<br>ii) Changes with time.<br>Replacement of items that fail completely: Individual replacement and Group | 15/12 hours |

| | | |
|---|---|---|
| | replacement policies.<br><br>**Game Theory:**<br>1) Definitions of Two person Zero Sum Game, Saddle Point, Value of the Game, Pure and Mixed strategy. Games without saddle point.<br>2) Optimal solution of two person zero sum games. Derivation of formulae for (2x2) game.<br>3) Graphical solution of (2xn) and (mx2) games. Dominance property, Iterative method.<br>4) Conversions of a game to L.P.P. | |
| **3** | **Information Theory:**<br>Introduction. Fundamental Theorem of Information Theory. Measures of Information. Properties of Entropy Function. Communication System. Memory less channel, Binary Symmetric channel, channel matrix, Joint, marginal and conditional Entropies.<br>$H(X,Y)= H(X/Y) + H(Y) =H(Y/X) + H(X)$ $H(X) \geq H(X/Y)$<br>Channel capacity, Efficiency and Redundancy, Encoding, Shannon – Fano Encoding Procedure, Shannon's Noiseless Coding Theory.<br><br>**Simulation:**<br>Scope of simulation application. Monte Carlo technique.<br>Generation of random numbers using : 1) Mid-square;<br>2) Multiplicative Congruential method<br>Generation of random numbers using : (i) Uniform; (ii) Poisson ; (iii) Rectangular; (iv) Exponential; (v) Normal, distributions.<br>Simulation technique's applied to Inventory and Queuing problems.<br>Sampling from probability distribution by inverse method for<br>1)Uniform distribution, 2) Exponential distribution | 15/12 hours |
| **4** | **Queuing Theory:**<br>Basic elements of the Queuing model. Kendalls Notation Roles of the Poisson and Exponential distributions.<br>Little's formulae,<br>Steady state probabilities and various average characteristics for the following models:<br>(i) (M/M/1) : (GD/ ∞ /∞)<br>(ii) (M/M/1) : (GD/ N/∞);<br>(iii) (M/M/c) : (GD/∞/∞)<br>(iv) (M/M/c) : (GD/ N /∞);<br>(v) (M/M/∞) :(GD/ ∞ /∞)<br>Waiting time Distributions. | 15.12 hours |
| | **Total** | **60** |
| **PRACTICALS** | | **60** |

## PRACTICALS

1. INVENTORY MODELS I
2. INVENTORY MODELS II

3. REPLACEMENT
4. GAME THEORY
5. INFORMATION THEORY
6. SIMULATION
7. QUEUEING THEORY –I
8. QUEUEING THEORY -II

**Suggested Readings**

| Sr. No. | Author | Title | Publisher |
|---|---|---|---|
| 1. | Taha Hamdy A. | Operations Research : Eighth edition | Prentice Hall of India Pvt. Ltd |
| 2. | Operations Research | H. A.Taha., 6th edition | Prentice Hall of India |
| 3. | J.K.Sharma, (2001) | Quantitative Techniques For Managerial Decisions | MacMillan India Ltd. |
| 4. | J K Sharma, (1989) | Mathematical Models in Operations Research | Tata McGraw Hill Publishing Company Ltd. |
| 5. | S.D.Sharma | Operations Research, 11$^{th}$ edition | KedarNath Ram Nath& Company |
| 6. | Kantiswaroop and Manmohan, Gupta | Operations Research, 12thEdition | S Chand & Sons |
| 7. | Richard Bronson | Schaum Series book in O.R., 2nd edition | Tata Mcgraw Hill Publishing Company Ltd. |
| 8. | Maurice Sasieni, Arthur Yaspan and Lawrence Friedman,(1959) | Operations Research: Methods and Problems | John Wiley & Sons. |
| 9 | Vora N. D. | Quantitative Techniques in Management, Third edition | McGraw Hill Companies |
| 10 | Bannerjee B. | Operation Research Techniques for Management, First edition. | Business Books |