## Description: Description: C:\Users\admin\Pictures\AUlogo.pngANNAMALAI UNIVERSITY

**202. B. Sc. Statistics**

Programme Structure and Scheme of Examination (under CBCS)

(Applicable to the candidates admitted in Affiliated Colleges

in the academic year 2022 -2023 ONLY)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Part** | **Study Components & Course Title** | **Hours/Week** | **Credit** | **Maximum Marks** |
| **CIA** | **ESE** | **Total** |
|  |  | **SEMESTER – I** |  |  |  |  |  |
| **22UTAML11** | I | **Language Course - I : Tamil-I** | 5 | 3 | 25 | 75 | 100 |
| **22UENGL12** | II | **English Course - I : Communicative English I** | 5 | 3 | 25 | 75 | 100 |
| 22USTAC13 | III | Core Course – I: **Descriptive Statistics** | 5 | 4 | 25 | 75 | 100 |
| 22USTAC14 | Core Course – II: **Probability Theory** | 5 | 4 | 25 | 75 | 100 |
|  | Core Practical – I: **Statistical Practical – I** | 3 | - | - | - | - |
| 22UMATA01 | Allied Course - I: Paper -1: **Mathematics – I** | 5 | 4 | 25 | 75 | 100 |
| **22UENVS18** | IV | **Environmental Studies** | 2 | 2 | 25 | 75 | 100 |
|  | **Total** | **30** | **20** |  |  | **600** |
|  |  | **SEMESTER – II** |  |  |  |  |  |
| **22UTAML21** | I | **Language Course - II: Tamil-II** | 5 | 3 | 25 | 75 | 100 |
| **22UENGL22** | II | **English Course - II: Communicative English II** | 5 | 3 | 25 | 75 | 100 |
| 22USTAC23 | III | Core Course – III: **Distribution Theory I** | 5 | 4 | 25 | 75 | 100 |
| 22USTAC24 | Core Practical – I:**Statistical Practical – I** | 3 | 2 | 40 | 60 | 100 |
| 22UMATA02 | Allied Course - II: Paper -2**Mathematics – II** | 4 | 4 | 25 | 75 | 100 |
| 22USTAE26 |  | Internal Elective – I (CHOOSE A OR B) | 3 | 3 | 25 | 75 | 100 |
| **22UVALE27** | IV | **Value Education** | 2 | 1 | 25 | 75 | 100 |
| **22USOFS28** | **Soft Skill** | 1 | 1 | 25 | 75 | 100 |
| **22UVMSD01** | **SDC** | **EFFECTIVE ENGLISH** | **2** | **2** | **25** | **75** | **100** |
|  | **Total** | **30** | **23** |  |  | **800** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **SEMESTER – III** |  |  |  |  |  |
| **22UTAML31** | I | **Language Course – III: Tamil - III**  | 5 | 3 | 25 | 75 | 100 |
| 22UENGL32 | II | English Course – III: English through literatures-I | 5 | 3 | 25 | 75 | 100 |
| 22USTAC33 | III | Core Course – IV: **Distribution Theory II** | 4 | 4 | 25 | 75 | 100 |
| 22USTAP34 | Core Practical – II: **Statistical Practical – II** | 3 | - | - | - | - |
| 22USTAA03 | Allied Course - III: Paper -1**Numerical Methods** | 4 | **3** | 25 | 75 | 100 |
|  | Allied Course – II: Allied Practical – 1 **Numerical Methods & Programming in C** | **2** | - | - | - | - |
| 22USTAE37 | Internal Elective – II: | 3 | 3 | 25 | 75 | 100 |
|  | IV | Non-Major Elective – I:  | 2 | 2 | 25 | 75 | 100 |
| 22USTAS39 | Skill Based Subject – I: **Elementary Mathematics** | 2 | 2 | 25 | 75 | 100 |
|  |  | **Total** | **30** | **20** |  |  | **700** |
|  |  | **SEMESTER – IV** |  |  |  |  |  |
| **22UTAML41** | I | **Language Course - IV: Tamil - IV**  | 5 | 3 | 25 | 75 | 100 |
| 22UENGL42 | II | English Course – IV: English through literature – II  | 4 | 3 | 25 | 75 | 100 |
| 22USTAC43 | III | Core Course – V: **Sampling Techniques** | 4 | 4 | 25 | 75 | 100 |
| 22USTAP44 | Core Practical – II: **Statistical Practical – II** | **4** | 2 | 40 | 60 | 100 |
| 22USTAA04 | Allied Course – IV Paper – 2 **Programming in C** | 4 | 4 | 25 | 75 | 100 |
| 22USTAAP02 | Allied Course - II: Allied Practical –1 **Numerical Methods & Programming in C** | 2 | 3 | 40 | 60 | 100 |
|  | IV | Non-Major Elective – II:  | 2 | 2 | 25 | 75 | 100 |
| 22USTAS48 | Skill Based Subject – II: **Statistical Data Analysis-I (Using R Programming)** | 2 | 2 | 25 | 75 | 100 |
| 22UNMS02 | IV | **MICROSOFT OFFICE ESSNTIALS**  | **2** | **2** | **25** | **75** | **100** |
|  |  |  | **30** | **25** |  |  | **900** |

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| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **SEMESTER – V** |  |  |  |  |  |
| 22USTAC51 | III | Core Course – VI: **Statistical Inference – I** | 4 | 4 | 25 | 75 | 100 |
| 22USTAC52 | Core Course – VII: **Statistical Quality Control** | 4 | 4 | 25 | 75 | 100 |
| 22USTAC53 | Core Course – VIII: **Applied Statistics** | 4 | 4 | 25 | 75 | 100 |
| 22USTAC54 | Core Course – IX: **Operation Research** | 4 | 4 | 25 | 75 | 100 |
| 22USTAP55 | Core Practical – III: **Statistical Practical – III** | **4** | - | - | - | - |
| 22USTAP56 | Core Practical – IV: **Statistical Data Analysis -Software Based** | 3 | - | - | - | - |
| 22USTAE58 | Internal Elective – III:  | 3 | 3 | 25 | 75 | 100 |
| 22USTAS59 | IV | Skill Based Subject – III: **Indian official Statistics** | 2 | 2 | 25 | 75 | 100 |
| **22UGENS57** | **Gender Studies** | 2 | 1 | 25 | 75 | 100 |
|  |  | **Total** | **30** | **22** |  |  | **700** |
|  |  | **SEMESTER – VI** |  |  |  |  |  |
| 22USTAC61 | III | Core Course – X: **Statistical Inference-II** | **5** | 4 | 25 | 75 | 100 |
| 22USTAC62 | Core Course – XI: **Regression analysis** | **5** | 4 | 25 | 75 | 100 |
| 22USTAC63 | Core Course – XII: **Design of Experiments** | **5** | 4 | 25 | 75 | 100 |
| 22USTAC64 | Core Course – XIII: **Stochastic Processes** | 4 | 4 | 25 | 75 | 100 |
| 22USTAP65 | Core Practical – III: **Statistical Practical – III** | 3 | 2 | 40 | 60 | 100 |
| 22USTAP66 | Core Practical – IV: **Statistical Data Analysis - Software Based** | 3 | 4 | 40 | 60 | 100 |
| 22USTAE68 | Internal Elective – IV: | 3 | 3 | 25 | 75 | 100 |
| 22USTAS69 | IV | Skill Based Subject – IV: **Econometrics** | 2 | 2 | 25 | 75 | 100 |
| **22UEXTA67** | V | **Extension Activities** |  | 1 | 100 | - | 100 |
| 22UNMSD03 | IV | **SALES FORCE (GOOGLE)** | **-** | **2** | **25** | **75** | **100** |
|  |  | **Total** | **30** | **30** |  |  | **1000** |
|  |  | **Grand Total** | **180** | **140** |  |  | **4800** |

**Internal Elective Courses**

|  |  |  |
| --- | --- | --- |
| 22USTAE26-1 | Internal Elective - I | Quantitative Aptitude |
| 22USTAE26-2 | Database Management System |
| 22USTAE37-1 | Internal Elective - II | Real Analysis-I |
| 22USTAE37-2 | Mathematical Economics |
| 22USTAE58-1 | Internal Elective - III | Statistical Genetics |
| 22USTAE58-2 | Programming with c ++ |
| 22USTAE68-1 | Internal Elective - IV | Demography |
| 22USTAE68-2 | Real Analysis-II |

**Allied Courses**

|  |  |  |
| --- | --- | --- |
| 22UMATA01 | Theory | Mathematics – I |
| 22UMATA02 | Theory | Mathematics – II |
| 22USTAA03 | Theory | Numerical Methods |
| 22USTAA04 | Theory | Programming in C |
| 22USTAAP02 | Practical | Numerical Methods & Programming in C |
| 22USMAA02 | Theory | Statistical Methods and their Applications |

**Non-Major Elective Courses (NME)**

(Department of Statistics offers the following NME to other Departments)

|  |  |
| --- | --- |
| 22USTAN38 | Statistical Methods – I |
| 22USTAN47 | Statistical Methods – II |

 **Credit Distribution**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Part** | **Study Components** | **Papers** | **Credits** | **Total Credits** | **Marks** | **Total Marks** |
| Part I | Languages | 4 | 3 | 12 | 100 | 400 |
| Part II | Communicative English & English | 4 | 3 | 12 | 100 | 400 |
| Part III | Core Courses | 13 | 4 | 52 | 100 | 1300 |
|  | Core Practical | 4 | 2,2,2,4 | 10 | 100 | 400 |
|  | Allied Courses | 4 | 4,4,3,4 | 15 | 100 | 400 |
|  | Allied Practical | 1 | 3 | 3 | 100 | 100 |
|  | Internal Electives | 4 | 3 | 12 | 100 | 400 |
| Part IV | Environmental Studies | 1 | 2 | 2 | 100 | 100 |
|  | Value Education | 1 | 1 | 1 | 100 | 100 |
|  | Soft Skill | 1 | 1 | 1 | 100 | 100 |
|  | Gender Studies | 1 | 1 | 1 | 100 | 100 |
|  | Non Major Electives | 2 | 2 | 4 | 100 | 200 |
|  | Skill Based Courses | 4 | 2 | 8 | 100 | 400 |
|  | SDC | 3 | 2 | 6 |  |  |
| Part V | Extension Activities | 1 | 1 | 1 | 100 | 100 |
|  |  | **48** |  | **140** |  | **4500** |

## Programme Outcomes

|  |  |
| --- | --- |
| PO1: | Domain knowledge: Demonstrate knowledge of basic concepts, principles and applications of the specific science discipline. |
| PO2: | Resource Utilisation. Cultivate the skills to acquire and use appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge-base and stay a breast of recent developments. |
| PO3: | Analytical and Technical Skills: Ability to handle/use appropriate tools/techniques/equipment with an understanding of the standard operating procedures, safety aspects/limitations. |
| PO4: | Critical thinking and Problem solving: Identify and critically analyse pertinent problemsintherelevantdisciplineusingappropriatetoolsandtechniquesaswellasapproachestoarrive available conclusions/solutions. |
| PO5: | Project Management: Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyse and interpret data and provide solutions. Exhibit organisational skills and the ability to manage time and resources. |
| PO6: | Individual and team work: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO7: | Effective Communication: Communicate effectively in spoken and written form as well as through electronic media with the scientific community as well as with society at large. Demonstrate the ability to write dissertations, reports, make effective presentations and documentation. |
| PO8: | Environment and Society: Analyse the impact of scientific and technological advances on the environment and society and the need for sustainable development. |
| PO9: | Ethics: Commitment to professional ethics and responsibilities. |
| PO10: | Life-long learning: Ability to engage in life-long learning in the context of the rapid developments in the discipline. |

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| **SEMESTER: I****PART: III** | **22USTAC13: DESCRIPTIVE STATISTICS****(CORE COURSE – I)** | **CREDIT:4****HOURS/week:5** |

**Course Objectives**

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| 1. To emphasis and enhance the basic statistical knowledge of the fresh students.
 |
| 1. To have knowledge on various statistical measures.
 |

**Unit I: Introduction Hours: 12**

Origin and Scope of Statistics; Definition of Statistics; Functions of Statistics; Applications of Statistics; Limitations of Statistics; Various types of Data; Nominal, Ordinal, Ratio Scale and Interval; Primary and Secondary Data; Methods of Collecting Primary Data; Drafting the questionnaire.

**Unit II: Classification of Statistical Data Hours:12**

Object of classification; Types of Classification; Formation of a Discrete Frequency Distribution; Formation of Continuous Frequency Distribution; Tabulation of data; Diagrammatic presentation of data; Graphs of Frequency Distribution; Histogram; Frequency Polygon; Ogives.

**Unit III: Univariate measures Hours:12**

Measures of Central Tendency; Objectives of Averaging; Requisites of a Good Average; Mean; Median; Mode; Geometric Mean; Harmonic Mean; Computation of Quartiles; Percentiles; Measures of Dispersion –Range; Mean Deviation; Standard Deviation; Co-efficient of Variation – Lorenz curve.

**Unit IV: Moments Hours:12**

Non-central moments; Central moments; Relationship between non-central and central moments; Measures of skewness; Karl Pearson’s coefficient of skewness; Bowley’s coefficient of skewness; Measures of Kurtosis; Types of Kurtosis.

**Unit V: Bi-variate measures Hours:12**

Scatter diagram Correlation; Types of Correlation; Methods of studying correlation; Karl Pearson’s coefficient of correlation; Properties of coefficient of correlation; Rank correlation coefficient; Regression; regression equations; types of regression; uses of regression.

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Study the basic concepts of statistics and data.
 |
| 1. Have knowledge on various diagrams and graphs.
 |
| 1. Calculate various measures of averages and dispersion
 |
| 1. Study the various measures of skewness and kurtosis.
 |
| 1. Study the measures of bivariate data
 |

**Text Books (In API Style)**

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| --- |
| 1. Gupta, S. C and Kapoor V. K. (2007). *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, New Delhi.
 |
| 1. Gupta, S. P.(2007). *Statistical Methods,* Sultan Chand & Sons, New Delhi.
 |
| 1. Goon Gupta, A. M. and Das Gupta. (1994).*Fundamentals of Statistic,* (Vol - I) Central Publisher, Calcutta.
 |

**Supplementary Readings**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1. Senthamaraikannan, K. and Venkatesan, D. (2006). *Introduction to Statistical Methods*, Scitech

 Publishers, Chennai.Mapping with Programme Outcomes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cos | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 2 | 1 | 3 | 1 |
| CO2 | 2 | 3 | 2 | 1 | 1 |
| CO3 | 2 | 2 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 2 |

**1:Low 2: Moderate 3: High** |  |  |  |  |  |
| **SEMESTER: I****PART: III** | **22USTAC 14: PROBABILITY THEORY****(CORE COURSE – II)** | **CREDIT:4****HOURS/week:5** |

**Course Objectives**

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| --- |
| 1. To study the basic concepts for promoting theoretical as well as applications of statistics. |
| 2. To study the limit theorems and convergence in probability. |

**Unit I: Probability Hours: 12**

Sample space – Events - algebraic operations on events. Definitions - Classical Probability, Statistical Probability, Axiomatic approach to probability - Independent events – Conditional probability -- Addition and Multiplication theorems of probability –Bayes Theorem.

**Unit II: Random variables Hours:12**

Discrete and continuous random variables –Distribution function- properties – Probability mass function and Probability density function – Discrete and continuous probability distributions.

**Unit III: Multiple Random Variables Hours:12**

Joint, marginal and conditional distributions independence of random variables –Transformation of random variables (one and two dimensional) and determination of their distributions.

**Unit IV: Mathematical Expectation Hours:12**

Expectation – Properties, Cauchy-Schwartz inequality, conditional expectation and conditional variance – theorems on expectation and conditional expectation. Moment generating function, cumulant generating function, characteristic function, probability generating function and their properties, Chebychev’s inequality

**Unit V: Limit Theorems Hours: 12**

Convergence in probability, weak law of large numbers - Bernoulli’s theorem, Khintchine’s theorem (Statements only) – Simple form of Central limit theorem for i.i.d random variables.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Study the various concepts of probability |
| 2. Understand a random variables probability functions. |
| 3. Study the bivariate probability functions. |
| 4. Understand the mathematical expectations and related functions. |
| 5. Study the law of large numbers. |

**Text Books (In API Style)**

1. Gupta, S.C. and Kapoor, V. K. (1982).Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.

2. Hogg, R.V. and Craig, A. G. (1978).Introduction to Mathematical Statistics,

MacMillan,London.

3. Mood, A.M.., Graybill, F. A.andBoes, D. C. (1974). Introduction to Theory of Statistics, TataMcGraw Hill, New Delhi.

4. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1993).Fundamentals of Statistics,Vol. I. World Press, Kolkata.

**Supplementary Readings**

1. Lipschutz, S. (2008).Probability Theory (Second Edition), Schaum’sOutline Series, McGraw Hill, New York.

2. Spiegel, M.R. and Ray, M. (1980).Theory and Problems of Probability and Statistics, Schaum’s Outline Series, McGraw Hill, New York.

Mapping with Programme Outcomes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cos | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 |
| CO4 | 2 | 2 | 3 | 3 | 2 |
| CO5 | 2 | 1 | 3 | 2 | 1 |

**1:Low 2: Moderate 3: High**

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| **SEMESTER: I****PART: III** | **22USTAP15: STATISTICAL PRACTICAL– I****(COREPRACTICAL – I)** | **CREDIT:-2****HOURS:3** |

**Course Objectives**

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| --- |
| 1. To acquire the knowledge to solve problems related to descriptive Statistics.  |
| 2.To acquire the knowledge to solve problems related to Probability. |

**Practical Schedule: -**(Based on Core Paper 1 and 2) **Hours: 36**

1. Calculation of Mean, Median, Mode, Geometric Mean and Harmonic Mean for raw data.

2. Calculation of Mean, Median and Mode for discrete data.

3. Calculation of Mean, Median and Mode for frequency distribution with Class Intervals.

4. Calculation of raw and central moments for raw data.

5. Calculation of raw and central moments for frequency distribution.

6. Calculation of range, Quartile Deviation, Standard Deviation, Mean Deviation, Coefficient of

Variation and Variance for raw data.

7. Calculation of range, Quartile Deviation, Standard Deviation, Mean Deviation, Coefficient of

Variation and their relative measures for frequency distribution.

8. Calculation of Pearson’s, Bowley’s Coefficient of Skewness and Kelly’s Coefficient of Skewness.

9. Calculation of Simple Correlation, Rank Correlation and Regression Coefficients.

10. Forming of Regression Lines and Predictions from Bivariate Data.

11. Construction of contingency table.

12. Association of Attributes.

13. Join Probability mass function, Join probability density function, Marginal probability mass and density functions.

14. Expectation, variance and Correlation coefficient.

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test (25 marks) and record work (15 marks). The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

Mapping with Programme Outcomes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cos | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 2 | 3 | 3 | 2 |
| CO2 | 1 | 2 | 3 | 3 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 2 | 2 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 3 | 3 |

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| --- | --- | --- |
| SEMESTER -IALLIED- I | 22UMATA01: MATHEMATICS – I | HRS/WK – 4CREDIT – 4 |

(For B.Sc Physics, Chemistry, Statistics and Computer Science)

COURSE OBJECTIVES

To acquire knowledge on finding roots of the Transcendental and Algebraic equations by Numerical methods, applications of matrices and Numerical methods for solving Simultaneous Linear equations. To understand the Computations of Eigen values ,Eigen vectors, differential calculus ,the evaluation of double and Triple integrals for finding Area and Volume.

UNIT-I: SOLUTIONS OF TRANSCENDENTAL AND ALGEBRAIC EQUATIONS

Iteration method**,** Bisection method, Newton’s method - Regula Falsi method, Horner’s method (without proof) (Simple problems only)

Unit-II: SOLUTIONS OF SIMULTANEOUS EQUATIONS

Gauss Elimination method- Gauss Jordan method-Gauss Seidel Iterative method-Gauss Jacobi method (Restricted to three variables only) (Simple problems only)

UNIT-III: MATRICES

Characteristic equation of a square matrix– Eigen values and eigen vectors – Cayley – Hamilton theorem [without proof] – Verification and computation of inverse matrix-

UNIT-IV: DIFFERENTIAL CALCULUS

n-th derivatives – Leibnitz theorem [without proof] and applications – Jacobians– Curvature and radius of curvature in Cartesian co-ordinates and polar co-ordinates.

UNIT-V: APPLICATION OF INTEGRATION

Evaluation of double, triple integrals – Simple applications to area, volume and centroid.

COURSE OUTCOMES

On successful completion of the course, the students will be able to

1. Attain knowledge on finding Approximate root for polynomial equations using Numerical methods.
2. Develop the skills of finding solutions of Simultaneous Linear equations.
3. Adopt techniques in solving problems involving Matrices
4. Provide skills on finding curvature and radius of curvature in Cartesian and polar co-ordinates.
5. Understand the applications of double and Triple integration in real life situation.

Text Books

1. A.Singaravelu “Numerical Methods”Meenakshi Publications

Unit-I: Chapter 2

Unit-II: Chapter 2

1. P. Duraipandian and Dr. S. Udayabaskaran. 1997, “Allied Mathematics” , Vol I & II. Chennai: Muhil Publishers.

Unit-III: Sec(1.1.1,1.1.2,1.2,1.4.3),

Unit-IV: Sec(2.7,4.1,4.1.1,4.2),

Unit-V: Chap:3(3.4,3.4.1,3.5,3.5.1,3.5.2,3.6)

Supplementary Readings

1. P. Balasubramanian and K. G. Subramanian. 1997, “Ancillary Mathematics”, Vol I & II. New Delhi: Tata McGraw Hill.
2. S.P.Rajagopalan and R.Sattanathan(2005), “Allied Mathematics”, Vol I & II. New Delhi: Vikas Publications.
3. P. R. Vittal (2003), “Allied Mathematics”,Chennai: Marghan Publications.

OUTCOME MAPPING

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 2 |
| CO5 | 2 | 3 | 3 | 3 | 2 |

1-Low 2-Moderate 3- High

|  |  |  |
| --- | --- | --- |
| **SEMESTER: II****PART: III** | **22USTAC23: DISTRIBUTION THEORY I****(CORE COURSE – III)** | **CREDIT:4****HOURS:5/week** |

**Course Objectives**

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| --- |
| 1. To build probability models for non-mathematical forms of real-life problems into mathematical forms. |
| 2. To emphasize relevance statistical tools to make decision on the real life problems. |
| 3. To have practical knowledge on fitting of various distributions. |

**Unit I: Hours: 12**

 Probability distributions. , introduction, Bernoulli Distribution,mean, variance, moment generating function , Binomial distribution, ,mean and variance of binomial distribution, factorial moments of Binomial distribution, Moment generating function, Characteristic function, cumulant Generating Function.Fitting of Binomial distribution, additive property of binomial distribution, Recurrence relations for probabilities of binomial distribution, simple problems

**Unit II: Hours:12**

Poisson distribution, characteristics of Poisson distribution ,mean and variance of Poisson distribution, factorial moments of Poisson distribution, Moment generating function, Characteristic function, cumulant Generating Function .Fitting of Poisson distribution, additive property of Poisson distribution, Recurrence relations for probabilities of Poisson distribution, simple problems

.**Unit III: Hours:12**

Negative binomial distribution ,derivation of Negative binomial distribution from Binomial distribution, Moment generating function,Cumulant generating function, Probability generating function of Negative binomial distribution, moments of negative binomial distribution, Fitting of negative binomial distribution,simple problems

**Unit IV: Hours:12**

Geometric distribution, Lack of memory, moments , and moment generating function of geometric distribution,Discrete Uniform Distribution, mean, variance , moment generating function, simple problems

**Unit V: Hours:12**

Hyper geometric distribution, Multinomial distribution and - Moments, Moment generating function, Characteristic function, Cumulant Generating Function of multinomial distribution, Generalised Power series distribution, Particular case of g.p.s.d.

**COURSE OUTCOME**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Understand the binomial Poisson distributions. |
| 2. Study the Poisson distributions. |
| 3. Study the negative Binomial distributions |
| 4. Study the geometric distributions. |
| 5. Study the hyper geometric distributions. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Hogg, R.V. and Craig, A. G. (1978).*Introduction to Mathematical Statistics*, MacMillan, London. |
| 2. Mood, A.M.,Graybill, F.A. and Boes, D.C(1974).*Introduction to Theory of Statistics*, Tata McGraw Hill, New Delhi |
| 3. Goon, A.M., Gupta M.K. and Das Gupta, B. (1993).*Fundamentals of Statistics,* Vol. I. World Press, Kolkata.4. Rohatgi, V.K and Saleh A. K MD.E. (2001).*An Introduction to Probability and Statistics*, Wiley,India.5. Gupta, S.C and Kapoor, V. K. (1982).*Fundamentals of Mathematical Statistics*, Sultan Chand& Sons, New Delhi. |

**Supplementary Readings**

|  |
| --- |
| 1. Spiegal, M.R. (1982).*Theory and problems of Probability and Statistics*, Schaum's outline series, McGraw Hill, New York. |
| 1. Spiegel, M.R. and Ray, M(1980).*Theory and Problems of Probability and Statistics*, Schaum’sOutline Series, McGraw Hill, New York.
2. AbhijitGuha. *Quantitative Aptitude by Competitive Examinations,* 4th edition.
 |

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |
|

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| EMESTER -IIALLIED- II | 22UMATA02: MATHEMATICS – II | HRS/WK – 4CREDIT – 4 |

(For B.Sc Physics, Chemistry, Statistics and Computer Science)COURSE OBJECTIVESTo expand trigonometric functions, solving partial differential equations and learn about vector differentiation and integration, also too familiar with physical interpretation of divergence and curl of a vector. Learning Finite differences and applications of Interpolations in real life situations.UNIT-I:TRIGONOMETRY Expansions of sin n θ, cos n θ, sinnθ,cosnθ, tannθ – Expansions of sinθ, cosθ, tanθ in terms of θ – Hyperbolic and inverse hyperbolic functions – Logarithms of complex numbers.Unit-I: Chap: 6 (6.1,6.1.1-6.1.3,6.2,6.2.1-6.2.3,6.3,6.4)UNIT-II: PARTIAL DIFFERENTIAL EQUATIONS Formation-complete integrals and general integrals-Four standard types-Lagranges equations.Unit-II: Chap:6 (6.1,6.1.1,6.2,6.3,6.4).UNIT-III: VECTOR DIFFRENTIATION Vector functions- Derivative of a vector function- Scalar and vector point functions- Gradient of a scalar point function- Gradient- Directional derivatives –Unit vector normal to a surface – angle between the surfaces-divergence, curl.Unit-IIISec(8.1,8.1.1,8.2,8.3,8.3.1,8.3.2,8.4,8.4.1,8.4.2,8.4.3,8.4.4).UNIT-IV: VECTOR INTEGRATION Green’s theorem in the plane- Gauss divergence theorem- Stoke’s theorem [without proofs].Unit-IV:Sec(8.6.1, - 8.6.3).UNIT-V: FINITE DIFFERENCES Operator E, Relation between  and E – Interpolation – Newton – Gregory forward & backward formulae for interpolation-Lagrange’s interpolation formula for unequal intervals(without proof) .Unit-V:Sec(5.1,5.2).COURSE OUTCOMESOn successful completion of the course, the students will be able to1. Attain knowledge on finding the expansions of trigonometric functions and concept of hyperbolic and inverse hyperbolic functions.
2. Provide a basic knowledge of Partial Differential equations and develops knowledge on handle practical problems.
3. Adopt techniques in solving problems involving vector and scalar functions
4. Provide skills on finding derivatives and gradients on vector differentiation and Integration.
5. Understand the applications of differentiation and integration in real life situation.

Text Books1. P. Duraipandian and S. Udayabaskaran(1997), “Allied Mathematics”, Vol I & II. Chennai: Muhil Publishers.

 Unit-I: Chap: 6 (6.1,6.1.1-6.1.3,6.2,6.2.1-6.2.3,6.3,6.4), Vol I, Unit-II: Chap:6 (6.1,6.1.1,6.2,6.3,6.4), Vol II, Unit-IIISec(8.1,8.1.1,8.2,8.3,8.3.1,8.3.2,8.4,8.4.1,8.4.2,8.4.3,8.4.4),Vol I, Unit-IV:Sec(8.6.1, - 8.6.3), Vol I, Unit-V:Sec(5.1,5.2), Vol II.Supplementary Readings1. P. Balasubramanian and K. G. Subramanian. 1997, “Ancillary Mathematics”, Vol I & II. New Delhi: Tata McGraw Hill.
2. S.P.Rajagopalan and R.Sattanathan(2005), “Allied Mathematics”, Vol I & II. New Delhi: Vikas Publications.
3. P. R. Vittal (2003), “Allied Mathematics”, Chennai: Marghan Publications.
4. P.Kandhasamy, K. Thilagavathy (2003), “Allied Mathematics” Vol I & II, New Delhi: Tata McGraw Hill.

OUTCOME MAPPING

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| --- | --- | --- | --- | --- | --- |
| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 2 |
| CO5 | 2 | 3 | 3 | 3 | 2 |

1-Low 2-Moderate 3- High**INTERNAL ELECTIVE – I**

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| **SEMESTER: II****PART:**  | **22USTAE26-1: QUANTITATIVE APPTITUDE** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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|  1. This course is designed to suit the need of the outgoing students. and  |
| 2. To acquaint them with frequently asked patterns in quantitative aptitude |
| 3. To acquaint them with logical reasoning during various examinations and campus interviews. |

**Unit I: Hours: 7**Ratio And Proportion, Percentages, Square root and Cube Root, Lowest Common Multiple (LCM) and Highest Common Factor (HCF).**Unit II: Hours:7**Logarithm, Permutation and Combinations, Simple Interest and Compound Interest.**Unit III: Hours:7**Time and Work, Time, Speed and Distance.**Unit IV: Hours:7**Data Interpretation, Tables, Column Graphs, Bar Graphs and Venn Diagrams.**Unit V: Hours: 8**Blood Relation, Coding and Decoding, Calendars and Seating Arrangements.**Course Outcomes**On successful completion of the course the students will be able to:

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| 1. Understand the basic concepts of quantitative ability |
| 2. Understand the basic concepts of logical reasoning Skills |
| 3. Acquire satisfactory competency in use of reasoning |
| 4. Solve campus placements aptitude papers covering Quantitative Ability, Logical Reasoning Ability. |
| 5. Compete in various competitive exams like CAT, CMAT, GATE, GRE, GATE, UPSC, GPSC etc. |

**Text Books (In API Style)**

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| 1. Agarwal , R. S. *A Modern Approach To Verbal & Non Verbal Reasoning* |
| 2. Sijwali, B. S. *Analytical and Logical reasoning.* |
| 3. Agarwal , R. S. *Quantitative aptitude for Competitive examination*. |

**Supplementary Readings**

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| --- |
| 1. Sijwali, B. S. *Analytical and Logical reasoning for CAT and other management entrance test* |
| 1. AbhijitGuha. *Quantitative Aptitude by Competitive Examinations,* 4th edition.

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: II****PART:** | **22USTAE26-2: DATA BASE MANAGEMENT SYSTEM** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. To enable the students to understand classifying and grouping and retrieve the mass data. |

**Unit I: Hours: 7**Introduction – DBMS Basic Concepts – Purpose of Database Systems – Database System/ File System – Overall System architecture – Database Languages – Classifications – Data Models.**Unit II: Hours:8**Entity relationship model: Mapping constraints – Primary Keys – Foregin Key – Structural Constraints – ER notations- ER model examples – Enhanced Entity Relationship Model: EER Concepts like Generalization, Specialization, Union, Category, Disjoint, Overlappingetc.EER model examples.**Unit III: Hours:7**Relational Data Base Design – ER/EER to Relational Mapping algorithm – Relational Model: Structure – Formal Query Languages – Relational Algebra – Informal Design Guidelines – Functional Dependencies – Normalization upto third Normal Form.**Unit IV: Hours:7**SQL – Basics of SQL – DDL – DML – DCL – TCL Commands in detail with examples.**Unit V: Hours: 7**PL/SQL: Stored Procedure Concepts – Procedure – Functions – Cursors – Triggers.**Course Outcomes** At the end of the course, the student will be able to:

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| 1. Study the introduction of DBMS concepts. |
| 2. Understand the concept of Entity relationship model. |
| 3. Understand the concept of Relational Data Base Design. |
| 4. Study SQL. |
| 5. Study PL/SQL. |

**Text Books (In API Style)**

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| 1. Korth, H. F. and Silberschatz, A. (1988).*Database system Concept*, McGraw Hill Publication. |
| 2. Albert Lulushi (1997). *Developing ORACLE FORMS Applications*, Prentice Hall. |
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**Supplementary Readings**

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| 1. Srinivasan, K. (1998).*Basic Demographic Techniques and Applications*.**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: III****PART: III** | **22USTAC33: DISTRIBUTION THEORY II****(CORE COURSE – IV)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| 1. To build probability models for non-mathematical forms of real-life problems into mathematical forms. |
| 2. To emphasize relevance statistical tools to make decision on the real life problems. |
|  3.To have practical knowledge on fitting of various distributions.**Unit I: Hours: 10**Continuous Distributions:Introduction,, Normal Distribution, Characteristics of normal distribution and normal curve, limiting case of binomial distribution,moment generating function, characteristic function, mean, median, mode of normal distribution, moment,area property, importance of normal distribution,Fitting of normal distribution**Unit II: Hours: 10** Exponential distribution, Moments, Moment generating function, Characteristic function, Cumulant Generating Function..Continuous Uniformdistribution,mean, variance ,moment generating function, characteristic function, simple problems**Unit III: Hours: 10**Gamma distribution,Moments, Moment generating function, Characteristic function, Cumulant Generating Function.Beta distribution of First kind and second kind, constants of Beta distribution of First kind and second kind, interrelationships between beta and gamma distributions**Unit IV: Hours: 8**Cauchy distribution, Characteristics and moments of Cauchy distribution, Distribution of random variables , , simple problems**Unit v: Hours: 10**Exact sampling distributions Functions of Normal random variables leading to t, Chi-square and F-distributions (derivations, properties and interrelationships) |

**COURSE OUTCOMES**

At the end of the course, the student will be able to:

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| 1. Understand the binomial Poisson distributions. |
| 2. Study the Poisson distributions. |
| 3. Study the negative Binomial distributions |
| 4. Study the geometric distributions. |
| 5. Study the hyper geometric distributions. |

**Text Books (In API Style)**

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| --- |
| 1. Hogg, R.V. and Craig, A. G. (1978).*Introduction to Mathematical Statistics*, MacMillan, London. |
| 2. Mood, A.M.,Graybill, F.A. and Boes, D.C(1974).*Introduction to Theory of Statistics*, Tata McGraw Hill, New Delhi |
| 3. Goon, A.M., Gupta M.K. and Das Gupta, B. (1993).*Fundamentals of Statistics,* Vol. I. World Press, Kolkata.4. Rohatgi, V.K and Saleh A. K MD.E. (2001).*An Introduction to Probability and Statistics*, Wiley,India.5. Gupta, S.C and Kapoor, V. K. (1982).*Fundamentals of Mathematical Statistics*, Sultan Chand& Sons, New Delhi. |

1. AbhijitGuha. *Quantitative Aptitude by Competitive Examinations,* 4th edition.

**Supplementary Readings**

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|  |
| 1. Spiegal, M.R. (1982).*Theory and problems of Probability and Statistics*, Schaum's outline series, McGraw Hill, New York. |
| 2. Spiegel, M.R. and Ray, M(1980).*Theory and Problems of Probability and Statistics*, Schaum’sOutline Series, McGraw Hill, New York. |

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: III****PART: III** | **22USTAC34: STATISTICAL PRACTICAL II****(CORE PRACTICAL – II)** | **CREDIT:****HOURS/week:3** |

**Course Objectives**

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| 1. To acquire the knowledge to solve problems related to Probability Distributions. |
| 2. To acquire the knowledge to solve problems related to sampling. |

**Practical Schedule: -** (Based on Core Paper 3 and 4) **Hours:36**

1. **Distribution Theory** (Problems related to fitting of various distributions such as binomial, poisson, normal, computation of correlation, partial and multiple correlation coefficients).

2. **Sampling Techniques** (Problems related to estimates of population mean and variance, under simple random sampling, stratified random sampling, systematic random sampling, ratio and regression estimators)

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test (25 marks) and record work (15 marks). The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: III****PART: III****ALLIED****COURSE - II** | **22USTAA03: NUMERICAL METHODS****(PAPER - I)** | **CREDIT:3****HOURS:4** |

**Course Objectives**

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| 1. To enable the students to establish mathematical functions using numerical data |
| 2.To study the knowledge of Interpolation, Numerical Differentiation and Integration. |
| 3. To familiarize in Numerical solution of ordinary differential equation |

**Unit I: Hours: 10**

Finite differences-forward and backward differences, operators E and ∆,and their basic properties, Interpolation with equal intervals: Newton’s forward and backward differences-simple problems.

**Unit II: Hours:10**

Interpolation with unequal intervals: Divided differences and their properties, Newton’s divided differences formula and Lagrange’s formula for interpolation-simple problems.

**Unit III: Hours:8**

Central difference interpolation formula-gauss forward and backward differences formulae- Stirling, Bessel’s Everett’s central difference formula.

**Unit IV: Hours:10**

Inverse interpolation-Lagrange’s method-iteration of successive approximation method- simple problems. Numerical differentiation- Numerical differentiation upto 2nd order only-simple problems.

**Unit V: Hours:10**

Numerical Integration-Trapezoidal rule-Simpsons 1/3rd and 3/8th rules-Weddle’s ruleEuler’s summation formula.Numerical method of solution of ordinary differential equations-Taylor’s series method-Euler method and RungaKutta upto second order – simple problems.

**Course Outcomes**

At the end of the course, the student will be able to:

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| 1. Understand the problems of numerical algebraic equations. |
| 2. Solve problems in linear algebraic equations. |
| 3. Understand the various methods of interpolation. |
| 4. Understand the various methods of numerical differentiation and integration. |
| 5. Solve problems of ordinary differential equations. |

**Text Books**

|  |
| --- |
| 1. Kandasamy,P.,Thilagavathy, K. and Gunavathi, K..*Numerical Methods*,S.Chand, New Delhi.  |
| 2.Venkataraman, M.K. *Numerical methods in Science and Engineering*, National publishing house, Chennai. |

**Supplementary Readings**

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| --- |
| 1. Gupta-Malik and Krishna PrakastanMandir.*Calculus of finite differences and Numerical analysis*, Meerut. |
| 2. Venkataraman, M.K. *Numerical methods in Science and Engineering*, National publishing house, Chennai.3. Sastry, S.S.*Introductory Methods of Numerical Analysis*,Printice Hall of India,New Delhi. |

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 2 | 3 | 3 |

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| **SEMESTER: III****PART: III** | **ALLIED COURSE – II: ALLIED PRACTICAL - 1****NUMERICAL METHODS & PROGRAMMING IN C** | **CREDIT:****HOURS:2** |

**Course Objectives**

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|  1. To enable students to solve problems related to numerical methods using programming in C. |

**Allied Practical – 1:-**(Based on Allied Papers 3 and 4) **hours 36**

**Summation of Series:**

1. Sin(x), 2. Cos(x), 3. Exp(x) (Comparison with built in functions)

**String Manipulation:**

1. Counting the no. of vowels, consonants, words, white spaces in a line of text and array of lines.

2. Reverse a string & check for palindrome.

3. Substring detection, count and removal

4. Finding and replacing substrings

**Matrix Manipulation:**

1. Addition & Subtraction

2. Multiplication

3. Transpose, and trace of a matrix

4. Determinant of a Matrix

Solution of polynomial equation - Newton Rapson method

Solution of system of simultaneous equation-Gauss elimination method. Lagrange interpolation.

Numerical integration by Trapezoidal, Simpson’s and Weddle’s rules.

Calculate the value of ∏ (up to five decimal places).

Check the accuracy of the built in functions Sin(x), Cos(x),(x in radians)ex , e -x Generation of Fibonacci Sequence.

Matrix addition, multiplication, inverse, transpose, determinant of square matrix.

Solution of simultaneous equations by Iterative methods and by using inverse.

**Text Books**

Books as prescribed in Allied papers in the semester III and IV.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Allied Practical-I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: III****PART: III** | **22USTAE37-1: REAL ANALYSIS I** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. To build the basis for promoting the aspects of sequences and series. |
| 2. To have knowledge on the operations of matrices. |

**UNIT – I 7 hours**

Sets: Sets - elements - Operations on set. Functions : Real valued functions equivalence - Countability - Real numbers - Upper and Lower bounds- Supremum and Infimum.

**UNIT – II 7 hours**

Sequence of real numbers : Limit of a sequence - Convergent sequences, Divergent sequences - Bounded sequences - Monotone sequences Cauchy s first and second theorem on limits Cauchy s general principle of convergence

**UNIT – III 8 hours**

Series of real numbers : Convergence and divergence - series with non-negative terms - comparison test D Alembert s ratio test, Cauchy s Root test – Alternating. Series - Conditional convergence and absolute convergence Leibnitz test.

**UNIT – IV 7 hours**

Functions: Limit of real valued functions in one variable, continuity types of discontinuities algebra of continuous functions Extreme value theorem. Intermediate value theorem Uniformly Continuous functions

**UNIT – V 7 hours**

Differentiability of Functions Rolle’s theorem Mean value theorem for derivatives. Taylor s Series expansion application to maxima and minima

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**Course Outcomes**

At the end of the course, the student will be able to:

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| 1. Understand the sequence of real numbers and related results. |
| 2. Understand the series of real numbers and related results. |
| 3. Study the limits and continuity. |
| 4. Understand the algebra of continuous functions |
| 1. understand the Differentiability of Functions
 |

**Text Books (In API Style)**

1. D. Somasundaram and B. Choudhary (2002) : A first course in Mathematical Analysis, Narosa Publishing house

2. R. R. Goldberg ( 1970) : Methods of Real Analysis, Oxford & IBH.

**Books for Reference:**

1. T. M. Apostol(1985) : Mathematical Analysis, Narosa Publishing House 2. W. Rudin(1976): Principles of Mathematical Analysis, 3/e, McGraw Hill Company.

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| **Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER:III****PART:** | **22USTAE37-2: MATHEMATICAL ECONOMICS** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. To enable the students to learn mathematical and statistical tools in Economics
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**Unit I: Hours:8**Scope and methods of Mathematical Economics – Laws of demand, Demand schedule (Individual and Market) - Demand function - Factors influencing the demand - Exception to the law of demand – Elasticity of demand with respect to price and income - Factors affecting the elasticity of demand - Partial elasticity of demand with respect to price - Simple problems in elasticity of demand.**Unit II: Hours:7**Supply - Factors affecting the supply of a commodity - Relation between demand and supply – Utility - Concept of utility - Concept of human wants - Maximization of utility - Marginal and total utility - Law of diminishing marginal utility - Indifference curves and map - Properties of indifference curve - Price line.**Unit III: Hours:7**Cost Analysis – Different types of cost - Total, average and marginal cost functions - Relation between average and marginal costs - Problems related to total, average and marginal costs – Revenue - Total, average and marginal revenue functions and their relationship - Simple problems related to maximization of total revenue**Unit IV: Hours:7**Market Structure – Definition of Market - Perfect completion - Pure competition - Monopolistic competition and duopolistic competition (Only concept) - Profit maximization – Profit function - Cournot solution to monopoly problem for maximization problem - Joint monopoly and discriminating monopoly - Problems related to profit maximization under monopoly. Duopoly - Conjectural variation and reaction curves - Simple maximization problem under duopoly.**Unit V: Hours: 7**Theoretical Production functions – Mathematical definition of production function - Constant product curves (Isoquant) - Average and marginal productivity - Homogenous production functions – Properties of linearly homogeneous production function – CobbDouglas production function – C. E. S. production function.**Course Outcomes**At the end of the course, the student will be able to:

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| --- |
| 1. Understand the Scope and methods of Mathematical Economics. |
| 2. Study the concept of Supply and Utility. |
| 3. Study the concept of cost analysis. |
| 4. Study the concept of Market Structure. |
| 5. Understand the theoretical production functions. |

**Text Books (In API Style)**

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| 1. Varma and Agarwal (1998).*Managerial Economics*, Sultan Chand and Company, New Delhi. |
| 2. Mehta and Madhnani (2001).*Mathematics for Economists*, Sultan Chand and Company,  New Delhi (Chapters 6, 8, and 9). |
| 3. Allen R.J.D. (1979).*Mathematical Economics*, Macmillan Press |

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 2 | 3 |

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| **SEMESTER:III****NME I** | **22USTAN38: STATISTICAL METHODS I** | **CREDIT:2****HOURS:2/week** |

 **Course Objective(s)**

To enable students to learn basics of statistics and its applications

**UNIT - I**

Statistics - Definitions - limitation of statistics - collection of data - primary data - secondary data - Diagrammatic and Graphical representation of data.

**UNIT - II**

Descriptive Measures - Mean, Median, mode, standard deviation, skewness and kurtosis (ungrouped data only).

**UNIT - III**

Concept of sample and Population - Preparation of questionnaire and Pre-testing - Simple random, Stratified random and Systematic sampling techniques.

**UNIT - IV**

Study of relationship between variables: Concept of correlation - Karl Pearson and Spearman rank correlation - simple problems. Qualitative: Contingency tables - Measures of Association. Concept of simple regression - simple problems.

**UNIT - V**

Elements of Compound interest (nominal and effective rates of interest, annuities certain, present values, accumulated amounts, deferred annuities) - the functions included in compound interest - tables and their uses.

**Course Outcomes**

1. After studied unit - 1, the student will be able to know visualization of data

2. After studied unit - 2, the student will be able to know computations of various statistical measures of data

3. After studied unit - 3, the student will be able to know sample selection and various sampling procedures

4. After studied unit - 4, the student will be able to know relationship among variables and fitting of simple regression model

5. After studied unit - 5, the student will be able to know computation of interest calculations

**Text Books:**

1. Gupta,S.P. (2014): Statistical Methods, Sultan Chand& Sons Pvt Ltd. New Delhi.
2. Federation of Insurance Institutes Study Courses - Mathematical Basis of Life Assurances F1,2.

**Reference Books:**

1. Kapoor, V.K. and Gupta, S.P. (1978): Fundamentals of Applied Statistics, Sultan Chand & Sons.

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: III****PART: IV** | **22USTAS39: ELEMENTARY MATHEMATICS** **(SKILL BASED SUBJECT – I)** | **CREDIT:2****HOURS:2/week** |

**Course Objectives**

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| 1. To enable the students to understand the Statistics concepts through the

mathematics |

**Unit I: Hours:5**

Descartes Rule of signs-Approximate Solutions of Polynomials by Horner’s method – Newton Rapson Method of solution of a cubic polynomial.

**Unit II: Unit Title Hours:5**

Prime Number – Composite Number – Decomposition of a Composite Number as a Product of primes uniquely (without Proof) - Divisors of a positive Integer – Congruence Modulo n – Euler Function (without Proof) – Highest power of a Prime Number p contained in n! – Fermat’s and Wilson’s Theorems (without Proof).

**Unit III: Unit Title Hours:5**

Power of sines and cosines of ϴ in terms of functions of multiples of ϴ -expansions of sin ϴ and cos ϴ in a series of ascending powers of ϴ.

**Unit IV: Unit Title Hours:4**

Definition – Relation between Hyperbolic Functions - Inverse Hyperbolic Functions.

**Unit V: Unit Title Hours: 5**

Summation of Trigonometric Series: When the angles are in A.P, C+ iS method of summation - Method of Differences - Gregory Series - Euler Series.

**Course Outcomes**

At the end of the course, the student will be able to:

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| 1. Acquire the basic concepts in theory of equations. |
| 2. Understand the concepts of elementary number theory. |
| 3. Understand the concepts of Trigonometry. |
| 4. Acquire the basic concepts of hyperbolic functions. |
| 1. Understand the concepts of summation of Trigonometric series.
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**Text Books (In API Style)**

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|  |
| 1. Kandasamy, P. and Thilagavathy, K. (2004).*Mathematic for B.Sc*. Vol.-I, II, III & IV, S.Chand& Company Ltd., New Delhi-55.2. Narayanan, S. and ManicavachagomPillay, T. K. (2004).*Calculus,* S.Viswanathan Printers & Publishers Pvt. Ltd. Chennai.**Supplementary Readings** |
|  |

1. ManicavachagomPillay, T. K., Natarajan, T. and Ganapathy, K. S. (2004).*Algebra*, Volume I & II S.Viswanathan Printers & Publishers Pvt. Ltd. Chennai.
2. Arumugam, S. (2003).*Algebra*, New Gamma Publishing House, Palayamkottai.
3. Singaravelu, A. (2003).*Algebra and Trigonometry*, Vol.-I & II Meenakshi Agency, Chennai.

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: IV****PART: III** | **22USTAC43: SAMPLING TECHNIQUES****(CORE COURSE – V)** | **CREDIT:4****HOURS:5/week** |

**Course Objectives**

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| 1. To learn the basic concepts and Applications of Sampling techniques for real life situations. |
| 2. To study the various Functions of NSS and CSO. |

**Unit I: Hours: 12**

Basic concepts of sample surveys – Principles of samples theory; sampling Unit; sampling frame; complete enumeration versus sampling; Merits and demerits; Basic concepts of sampling distribution; Unbiasedness; Mean square error and relative standard error.

**Unit II: Hours:12**

Simple random sampling with and without replacement; Lottery method - Use of random number tables; Estimation of population parameters; Mean; Variance and proportion; simple random sampling for proportion.

**Unit III: Hours:12**

Stratified random sampling - Principle of stratification; Estimation of population mean and variance; Allocation techniques; equal allocation; proportional allocation; Neyman’s allocation and optimum allocation.

**Unit IV: Hours:12**

Systematic sampling Estimation of mean and its sampling variance – Comparison of simple; stratified and systematic sampling.

**Unit V: Hours:12**

Functions of NSS and CSO; Sampling errors; Non – sampling errors; Sources of non – sampling errors.

**Course Outcomes**

At the end of the course, the student will be able to:

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| 1. Understand the concepts of census and sample surveys. |
| 2. Study the concepts of simple random sampling. |
| 3. Study the concepts of stratified random sampling. |
| 4. Study the concepts of systematic sampling. |
| 5. Study the functions of national sample survey. |

**Text Books (In API Style)**

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| 1. Daroga Singh and Choudary F.S. (1996).*Theory and analysis of sample survery designs*, New Age International Publishers, New Delhi. |
| 2.Sampath.S. (2001),*SamplingTheory,*Narasa Publishing house, New Delhi. |
| 3. Gupta S.C and Kapoor V.K. (2007).*Fundaments of Applied Statistics*, Sultan Chand and Company, 4th Edition, New Delhi.4.Desraj. (1997).*Sampling Theory*, New Age International Pvt. Ltd. New Delhi.5. Murthy,MN.*Sampling: Theory and Methods*, ISI Publications, Calcutta. |

**Supplementary Readings**

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|  |
| 1. William G. Cocharan, (2008).*Sampling Techniques*, John wiley sons, New York. |
| 2. SukhatameP.V and Sukhatame B.V. (1957).*Sampling theory of surveys with applications,* ISAS Publishers 3rd Edition. |

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: IV****PART: III** | **22USTAP44: STATISTICAL PRACTICAL II****(CORE PRACTICAL – II)** | **CREDIT:4****HOURS:3/week** |

**Course Objectives**

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| --- |
| 1. To acquire the knowledge to solve problems related to Probability Distributions. |
| 2. To acquire the knowledge to solve problems related to sampling. |

**Practical Schedule: -** (Based on Core Paper 3 and 4) **Hours:36**

1. **Distribution Theory** (Problems related to fitting of various distributions such as binomial, poisson,

normal, computation of correlation, partial and multiple correlation coefficients).

2. **Sampling Techniques** (Problems related to estimates of population mean and variance, under

simple random sampling, stratified random sampling, systematic random sampling, ratio and

regression estimators)

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test (25 marks) and record work (15 marks). The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: IV****PART: III** | **ALLIED COURSE - II: 22USTAA04: PROGRAMMING IN C** **(PAPER – II)** | **CREDIT:4****HOURS:3/week** |

**Course Objectives**

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| 1.To enable the students to understand and develop programs in C. |

**Unit I: Unit Title Hours: 8**

Introduction to “C”, variables, data types-declarations, type conversions, increment and decrement, Bitwise, Logical and Assignment operators.

**Unit II: Unit Title Hours:10**

Expression and conditional expressions, control structures, If-Else, SWITCH, WHILE, FOR and DO WHILE loop structures. Break continue, GO and Label statements. Function, function returning, Non-integers, Function arguments -Static and register variables.

**Unit III: Unit Title Hours:10**

Arrays and Strings - Array Declaration, Multidimensional Arrays String, Character Arrays, Array initialization-Pointers and addresses. Pointers and Arrays-Pointer to function.

**Unit IV: Unit Title Hours:10**

Structures and functions, Array of structures Fields, Unions-type definition standard input and output - formatted output - output - Access to the standard library.

**Unit V: Unit Title Hours: 10**

File Access, File handling in C - File descriptions - Error handling - ‘Low level i/o-Read and Write’. Open, Create, Close, Unlike-Random Access - seek and I seek.

**Course Outcomes**

At the end of the course, the student will be able to:

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| 1. The student will be able to know the basic data types of programming in C. |
| 2. The student will be able to know the various control structures and its usage. |
| 3. The student will be able to know the concept of arrays and pointers. |
| 4. The student will be able to know the concept of structures and unions. |
| 5. The student will be able to know to file structures and its manipulations. |

**Text Books (In API Style)**

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| 1. Balagurusamy, E. (1997).*ANSI ‘C’ Programming*, Tata-McGraw Hill Publishers Ltd.2. YaswantKanetkar. (1997). *Let Us ‘C’*,B P B Publications, New Delhi. |
|  3. Bruce,H.Hunter. *Introduction to ‘C’.***Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: IV****PART: III** | **ALLIED COURSE - II: ALLIED PRACTICAL - I****22USTAAP02: NUMERICAL METHODS & PROGRAMMING IN C** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. To enable students to solve problems related to numerical methods using  programming in C. |
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**Allied Practical – 1:-**(Based on Allied Papers 3 and 4) **hours 36**

**Summation of Series:**

1. Sin(x), 2. Cos(x), 3. Exp(x) (Comparison with built in functions)

**String Manipulation:**

1. Counting the no. of vowels, consonants, words, white spaces in a line of text and array of lines.

2. Reverse a string & check for palindrome.

3. Substring detection, count and removal

4. Finding and replacing substrings

**Matrix Manipulation:**

1. Addition & Subtraction

2. Multiplication

3. Transpose, and trace of a matrix

4. Determinant of a Matrix

Solution of polynomial equation - Newton Rapson method

Solution of system of simultaneous equation-Gauss elimination method. Lagrange interpolation.

Numerical integration by Trapezoidal, Simpson’s and Weddle’s rules.

Calculate the value of ∏ (up to five decimal places).

Check the accuracy of the built in functions Sin(x), Cos(x),(x in radians)ex , e -x Generation of Fibonacci Sequence.

Matrix addition, multiplication, inverse, transpose, determinant of square matrix.

Solution of simultaneous equations by Iterative methods and by using inverse.

**Text Books**

Books as prescribed in Allied papers in the semester III and IV.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Allied Practical-I shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**Outcome Mapping**

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| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 2 | 3 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 33 | 3 |
| **CO4** | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 3 | 2 |

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| **SEMESTER:IV****NME II** | **22USTAN47: STATISTICAL METHODS II** | **CREDIT:2****HOURS:2/week** |

**Course Objective(s)**

To enable students to learn the concept of estimation of unknown parameters of the population and hypothesis testing problem.

**UNIT - I**

Population growth and change - arithmetic, geometric and exponential growth rates - Population estimation and projection.

**UNIT - II**

Measures of mortality - Crude and Specific rates- Infant mortality rate - direct and indirect standardization of death rates - Complete life table.

**UNIT - III**

Estimation - Point estimation - interval estimation - mean - variance - proportions - simple problems.

**UNIT - IV**

Parametric Tests - Testing of significance of small and large sample tests - t-test, chi-square test - F test - z-test.

**UNIT - V**

Non- Parametric tests - Sign test, Wilcoxon test, Mann-Whitney U Test. Median test, Run test, Kolmogorov - Smirnov One Sample test. Chi- Square Tests - Goodness of fit - Test of independence of attributes.

**Course Outcomes**

**CLO** 1. After studied unit - 1, the student will be able to know computation of population growth rate

**CLO** 2. After studied unit - 2, the student will be able to know the concept of mortality and its calculations

**CLO** 3. After studied unit - 3, the student will be able to know the concept of estimation of parameter

**CLO** 4. After studied unit - 4, the student will be able to know various parametric testing procedures

**CLO** 5. After studied unit - , the student will be able to know various Non parametric testing procedures

**Text Books:**

1. Gupta,S.P (2014): Statistical Methods, Sultan Chand & Sons .

2**.** Kapoor, V.K. and Gupta, S.P. (1978): Fundamentals of Applied Statistics, Sultan Chand & Sons.

**Reference Books:**

1. Rohatgi, V.K. (1984) An introduction to probability theory and Mathematical Statistics, Wiley Eastern.

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: IV****PART: IV** | **22USTAS48: Statistical Data Analysis i (USING r PROGRAMMING)(SKILL BASED SUBJECT – II)** | **CREDIT:2****HOURS:2/week** |

**Course Objectives**1. To enlighten the students to acquire skills for adopting statistical tools and techniques of data analysis.
2. To enable students to utilize the theoretical knowledge gained in the corePapers and to develop computational and technical skills for real life applications emphasizing the importance of R programming.

**Unit I: Hours:5** Using R command - Operations on vectors and matrices**.** Creating and Manipulation of **data** frames **-** user-defined functions. **Unit II: Hours:5**Matrix addition, multiplication, inverse, transpose, determinant and trace of matrix Construction of table with one or more variables. Graphical procedures- Pie chart, Bar chart, Histograms and Boxplots.**Unit III: Hours:4** Computation of various descriptive measures such as Measures of central tendency**,**measures of dispersion, skewness and kurtosis. Computation of  Correlations and regression **co-**efficient.**Unit IV: Hours:5** Computation of probabilities using various distributions Binomial, Poisson and Normal **Unit V: Hours: 5**selection of samples using various sampling techniques, methods and procedures.**Course Outcomes** At the end of the course, the student will be able to:

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| 1. Understand the various concepts of statistical tests and to apply large sample tests. |
| 2. Apply the exact tests for research problems. |
| 3. Apply the various chi-square tests. |
| 4. Apply the multiple regression analysis and multivariate tests for real life problems. |
| 5. Apply the non-parametric tests for sample data. |

**Text Books (In API Style)**1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi.

  **Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: V****PART: III** | **22USTAC51: STATISTICAL INFERENCE I****(CORE COURSE – VI)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| 1. To enable the students to understand the sampling distributions. and  |
| 2. To apply various estimation procedures. |

**Unit I: Hours:10**

Sampling distributions - concept - distributions of mean and variance from Normal population. Sampling distributions: Chi-square, Student’s t and F distributions - Derivation of their density functions and their properties

**Unit II: Hours:10**

Point Estimation - Problem of Point estimation - Properties of estimators- Consistency and Efficiency of an estimator. Sufficiency of a statistic - Neyman- Fisher factorization theorem (discrete case) - Simple problems.

**Unit III: Hours:8**

Unbiasedness - Properties, MVUE, BLUE, Rao - Blackwell theorem -Sufficiency and completeness, Lehman- Scheffe theorem, Cramer- Rao inequality - simple problems.

**Unit IV: Hours:10**

Methods of estimation: Method of Moments, Method of Maximum Likelihood, Method of minimum chi-square, Method of modified minimum chi-square, method of least squares-properties of estimators obtained by these methods -simple problems.

**Unit V: Hours: 10**

Interval Estimation - Confidence Interval for proportions, mean(s), variance, and variance ratio based on chi square, student's t, F and Normal distributions. Tests of significance: concepts - tests based on normal, t, F, and Chi Square.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Study the sampling distribution and their concept. |
| 2.Understand point estimation and their properties. |
| 3. Study the concept of unbiasedness. |
| 4. Understand the method of estimation. |
| 5. Understand interval estimation. |

**Text Books (In API Style)**

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| 1. Mood, AM.,Graybill, F.A. and Boes, D.C. (1974).*Introduction to the Theory of Statistics*, McGraw Hill. |
| 2. Hogg R.V. and Craig, A.T. (1972).*Introduction to Mathematical Statistics*, 3rd edition, Academic Press, USA. |
| 3. Goon, A.M. Gupta, M.K., and Das Gupta, B. (1980).*An outline of statistical theory*, Vol.I, 6threvised ed. World Press limited, Calcutta.4. Rohatgi, V.K. (1984).*AnIntroduction to Probability Theory and Mathematical Statistics*, WileyEastern.5. Spiegal, M.R. (1982).*Theory and Problems of Probability and Statistics*, Schaum's outline series, McGraw Hill |

**Supplementary Readings**

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|  |
| 1. Hoel, P.G. (1971).*Introduction to Mathematical Statistics*, Asia Publishing House. |
| 2. Degroot, M.H. (1975).*Probability and Statistics*, Addison – Wesley. |

 **MAPPING WITH PROGRAMME OUTCOMES**

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| --- | --- | --- | --- | --- | --- |
|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 3 | 3 | 2 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 3 |
| CO3 | 2 | 3 | 3 | 2 | 3 |
| CO4 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 |

**1:** Low; **2:** Moderate; **3:** High

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| **SEMESTER: V****PART: III** | **22USTAC52: STATISTICAL QUALITY CONTROL****(CORE COURSE – VII)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| 1. To understand the need of quality improvement, total quality management. |
| 2. To understand the need of statistical plots and tools such as SPC, CUSUM and ISO. |

**Unit I: Hours: 10**

Control charts for variables: Need for Statistical Quality Control techniques in Industry – Causes of Quality variation – Uses of Shewart Control charts – specifications, tolerance limits – 3σ limits – warning limits -X̅, F and σ- charts – Basis of sub grouping – Interpretation of X̅, R charts.

**Unit II: Hours:10**

Control charts for attributes: p, np, c and u charts. Construction of charts – choice between p and np charts.

**Unit III: Hours:10**

Acceptance Sampling: Sampling inspection – inspection by attributes and variables - concepts of Producer’s risk, Consumer’s risk. AQL, LTPD, AOQ, AOQL, ATI and ASN. Rectifying inspection plans.

**Unit IV: Hours:8**

Acceptance sampling for attributes: Single and Double sampling plans. OC, AOQ, ATI and ASN curves for Single and Double sampling plans.

**Unit V: Hours:10**

Acceptance sampling for variables: Known and unknown sampling plans (one sided specification only). Determination of n and k for one sided specification of OC curve.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Understand the concepts of control charts for variables. |
| 2. Understand the concepts of control charts for attributes. |
| 3. Study the concepts of acceptance sampling. |
| 4. Study the single and double sampling plans. |
| 5. Study the acceptance sampling for variables. |

**Text Books (In API Style)**

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| --- |
| 1. Kapoor, V.K. and Gupta, S.P. (2007).*Fundamentals of Applied Statistics*, Sultan Chand&Sons. |
| 2. Gupta, R.C, (1974).*Statistical Quality Control*, Khanna Publishing Co, New Delhi |
| 3. Montgomery, D.C, (1983).*Introduction to Statistical Quality Control*, Wiley,New York.4. Grant, E.L. and Leavenworth, R.S, (1996).*Statistical Quality Control*, McGraw Hill, New York.**Supplementary Readings**1. Mahajan. (1997).*Statistical Quality Control*, Dhanpatrai& Sons, New Delhi. |
| 2. Juran J. M. (1999).*Juran’s Quality Hand Book*, McGraw Hill, New York. |
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**MAPPING WITH PROGRAMME OUTCOMES**

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| --- | --- | --- | --- | --- | --- |
|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 2 | 3 | 2 |
| CO2 | 2 | 2 | 2 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 2 | 3 |
| CO4 | 2 | 3 | 3 | 2 | 2 |
| CO5 | 3 | 2 | 3 | 3 | 3 |

**1:** Low; **2:** Moderate; **3:** High

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| **SEMESTER: V****PART: III** | **22USTAC53: APPLIED STATISTICS****(CORE COURSE – VIII)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| 1. To introduce the basic Statistical tools in time related Variables, economic variables. |
| 2. To enable the students understand index numbers and other Statistical tools applied to  demographic and chorological data |

**Unit I: Hours: 10**

Time series - Concept - Components of time Series - Additive and multiplicative models - Measurement of trend – free hand method-semi average method-Moving average method - Least square method.

**Unit II: Hours:8**

Measurement of seasonal variations - Simple average method - Ratio to trend method - Ratio to moving average method - Link relative method - Variate Difference method.

**Unit III: Hours:10**

Index Numbers - uses, classification of index numbers - Problems in the construction of index numbers - Methods of constructing index numbers - Unweighted index numbers - weighted index numbers.

**Unit IV: Hours:10**

Quantity index numbers - Fixed and chain base index numbers - Optimum test for index numbers - Time reversal test - factor reversal test - cost of living index numbers.

**Unit V: Hours: 10**

Demand Analysis Theory and analysis of consumer s demand Law of demand, Price elasticity of demand estimation of demand curves forms of demand functions - Demand and Supply utility and indifference maps determination of price and supply and demand

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Study the various components of time series models. |
| 2. Study the measurement of seasonal variations. |
| 3. Study the various types of index numbers. |
| 4. Apply the tools of time series concepts for given data. |
| 5. Study the demand analysis theory. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Kapoor,V.K and Gupta,S.C (1978).*Fundamentals of Applied Statistics*, Sultan Chand & Sons. |
| 2. Gupta, S.P (1999).*Statistical Methods*, Sultan & Sons, New Delhi. |

**Supplementary Readings**

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|  |
| 1. Croxton, F.E&Cowdon, D.J. (1973).*Applied General Statistics*, Prentice Hall |
| 2. Mukhopadhyay,P.(1999).*Applied Statistics*,New Central Book Agency Pvt.Ltd.,Calcutta. |

 **MAPPING WITH PROGRAMME OUTCOMES**

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| --- | --- | --- | --- | --- | --- |
|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 2 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 2 |
| CO3 | 2 | 3 | 3 | 2 | 3 |
| CO4 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 2 | 3 |

**1:** Low; **2:** Moderate; **3:** High

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| **SEMESTER: V****PART: III** | **22USTAC54: OPERATION RESEARCH****(CORE COURSE – IX)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| 1. To import knowledge of various optimization techniques that makes use of statistical concepts abundantly. |
| 2. To apply the various optimization techniques in real life situations |
| 3. To have knowledge on decision making |

**Unit I: Hours:10**

Introduction to OR, Nature, Scope, Functions, Linear programming problem - Formulation of LPP - Solving the LPP by graphical method.

**Unit II: Hours:8**

Solving the LPP by simplex method, Big-M method, Duality in LPP, Dual simplex method.

**Unit III: Hours:10**

Transportation problem- obtaining initial, feasible and optimal solutions. Optimality test degeneracy, Unbalanced transportation problem, Assignment problem, and unbalanced assignment problem - Traveling salesman problem.

**Unit IV: Hours:10**

Game Theory - Two-person zero sum games, The maximin - minimax principle - Games without saddle points - Mixed strategies - Graphical solution of 2xn and mx2 games Dominance property. Sequencing - 'n' jobs through 2 machines - 'n' jobs through 3 machines - 'n' jobs through ‘m’ machines, Two jobs and 'm' machines.

**Unit V: Hours: 10**

Network analysis by CPM / PERT basic concepts - constraints in Network - construction of the network - Time calculations - Concepts of slack and float in Network Analysis - finding optimum project duration and minimum project cost, finding expected project time and variance.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Understand the general LPP |
| 2. Apply the integer programming problem. |
| 3. Solve game problems in real life study. |
| 4. Apply CPM/PERT techniques practically. |
| 5. Apply the inventory system in economic problems.  |

**Text Books (In API Style)**

|  |
| --- |
| 1. Kanti Swamp et al.*Operations Research*, Suichand and Sons, New Delhi. |
| 2. Sharma J.K. (2001).*Operations Research. Theory and Applications*, Macmillan India Ltd. |
| 3. Prem Kumar Gupta and Hira, D.S. (2010).*Problems in Operations Research*, S. Chand and Company Limited, New Delhi.4. Cheema, Col.D.S,(2005).*Operation Research*, Laxmi Publications (P) Ltd., New Delhi.5. Sharma, S.D. (2002).*OperationsResearch,*Kedarnath and Ramnath, Meerut. |

**Supplementary Readings**

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| --- |
|  |
| 1. Gupta R.K.(1985).*Operations Research*, Krishna Prakashan, Mandir, Meerut. |
| 2. Handy A. Taha (1996).*Operations Research*, 6 Ed. Prentice Hall of India. |

**MAPPING WITH PROGRAMME OUTCOMES**

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|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 3 | 2 | 3 |

**1:** Low; **2:** Moderate; **3:** High

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| **SEMESTER: V****PART: III** | **22USTAP55: STATISTICAL PRACTICAL – III****(CORE PRACTICAL – III)** | **CREDIT:****HOURS:3** |

**Course Objectives**

 To enable students to solve problems related to estimation and hypothesis testing, statistical quality control techniques and design and analysis of experiments

**Practical Schedule: - total hrs 36**

Problems relating to the following topics which are covered in Semester V and Semester VI shall form the basis for practical:

1. **Estimation theory** (problems related to estimation of parameters under various methods, confidence intervals for mean, variance and proportions)
2. **Statistical Quality Control** (Control charts for variables and attributes).
3. **Testing of Statistical Hypotheses** (problem related to test of significance of mean, variances, one sample, two samples and more than two samples, non-parametric tests)
4. **Design and Analysis ofExperiments**(problem related to CRD, RBD, LSD, Missing Plot Techniques, Factorial experiments 22, 23, 32)

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical-III shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test (25 marks) and record work (15 marks). The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**MAPPING WITH PROGRAMME OUTCOMES**

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|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 3 | 3 | 3 |
| CO2 | 2 | 3 | 3 | 2 | 3 |
| CO3 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 2 | 3 | 3 | 3 | 3 |
| CO5 | 2 | 2 | 3 | 2 | 3 |

**1:** Low; **2:** Moderate; **3:** High

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| **SEMESTER: V****PART: III** | **22USTAP56: STATISTICAL DATA ANALYSIS- SOFTWARE BASED (CORE PRACTICAL – IV)** | **CREDIT:****HOURS:3** |

**Course Objectives**

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| --- |
|  1.To enable students to utilize the theoretical knowledge gained in the core papers and to  develop computational and technical skills for real life applications emphasizing the importance of statistical software programming. |

**Practical Schedule: total hours 36-**

To compute the various statistical measures using statistical software SPSS.

1. Tabulation and diagrammatical representation of data.
2. Measures of Central Tendency, Dispersion, Skewness and Kurtosis
3. Correlation and Regression, simple and multiple linear regression.
4. Parametric tests: t-test, F-test, chi-square test.
5. Analysis of variance: One-way Classification, Two-way Classification.
6. Non-parametric tests: Sign test, Wilcoxon test, Mann-Whitney U test, Median test, Run test, Kolmogorov Smirnov test, Kruskal Wallis test.
7. Statistical Quality control charts for variables
8. Statistical Quality control charts for attributes

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Data Analysis-II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**MAPPING WITH PROGRAMME OUTCOMES**

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|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 3 | 2 | 3 |

**1:** Low; **2:** Moderate; **3:** High

**INTERNAL ELECTIVE – III**

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| **SEMESTER: V****PART:** | **22USTAE58-1: STATISTICAL GENETICS** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. To enhance the students apply statistical methods in Genetics. |

**Unit I: Unit Title Hours: 7**

Statistics Genetics: Cells, Chromosomes, Gametes, Genes and Gene frequency, Mendel’s law – Single locus with two alleles – Hardy-Weinberg equilibrium – A-B-O blood group system, Calculation of Probabilities of offspring blood group for given parental blood group – Chance of incompatibility.

**Unit II: Unit Title Hours:7**

Definition of ED50, ED90 etc. – Simple method of estimation of the above. Data: Dose levels (Z, I), number of individuals exposed (n, l), number responding (r, l). Simple regression of probit on log dose to estimate parameters of tolerance distribution.

**Unit III: Unit Title Hours:8**

Introduction to logistic regression with binary response and one independent variables (continuous) – Exponential and logistic model of population growth, solving the following differential equations: DNt /dt=kNt, dNt(k-Nt). Fitting the above growth models to data by linearization and regression.

**Unit IV: Unit Title Hours:7**

Capture-recapture method of abundance estimation. One and two recapture occasions. Use of likelihood under binomial distribution – Concept of biodiversity.Simpsons and Shannon-Wiener indices.

**Unit V: Unit Title Hours: 7**

Study of exponential and Weibull distributions as models for survivorship data.Corresponding hazard functions and interpretation of their shapes.Applications to environmental data.

**Course Outcomes**

 At the end of the course, the student will be able to:

|  |
| --- |
| 1. Study the concepts of Statistics Genetics. |
| 2. Study the definitions of Genetics. |
| 3. Understand the concept of logistic regression. |
| 4. Study capture and recapture methods. |
| 5. Study of some statistical distributions. |

**Text Books (In API Style)**

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| --- |
| 1. Finney, D. J. (1978). *Statistical Methods in Biological Assays*, Charles Griffics& Co. |

2. Gore, A. P. andParanjpe, S. A. (2000). *A course in Mathematical & Statistical Ecology*, Kluwer.

**Supplementary Readings**

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| 1. Elandt Johnson, R. C. (1975). *Probability Models and Statistical Methods in Genetics* Wiley.2. Li, C. C. (1976). *First course in Population Genetics*, Boxwood Press.**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 3 |
| **CO5** | 3 | 3 | 2 | 3 | 23 |

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|  **SEMESTER: V****PART:**  | **22USTAE58-2: PROGRAMMING WITH C++** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1. This paper aims at introducing the language C++ in a systematic manner to make the

students to have knowledge in program writing and developing the software. |
| 1. To learn structures in C++
 |
| 3. To understand the usage of classes and objects. |

**Unit I:**

C++: Introduction, Data types, Operators, Statements; Declaration of variables, Statements, simple C++ programs, Features of I/O stream, manipulation function, I/O stream flags.

**Unit II: Hours:8**

Control Statements: Conditional expression, Switch statement, loop statements, Breaking control statements; Functions and Program structures; Introduction, definition, Types of functions, Actual and Formal arguments, Default augments, Storage class specifies, Recursive function, Pre-processors, Header files and standard function.

**Unit III: Hours:7**

Arrays: Notation, Declaration, Initialization, Processing, Arrays and Functions, Multidimensional arrays. Pointers; Declaration, Arithmetic; Pointers and Functions, Pointers and Arrays; Strings, Array of Pointers, Pointers to Pointers.

**Unit IV: Hours:7**

Structures: Declaration, Initialization, Functions, Array of structures, Arrays within a structure, Nested Structures, Pointers and Structures, Unions and Bit fields, Enumerations.

**Unit V: Hours:7**

Classes and Objects: Introduction, Structures and classes, Declaration, Members Functions, Object a class, Array of class objects, Pointers and Classes, Unions and Classes, nested Class, Constructors and Destructors, Inline Members functions and Friend Functions. C++ programs for Descriptive Measures of Statistics.

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Understand the fundamental concepts of C++ programming. |
| 2. Understand the various statements of C++. |
| 3. Study the arrays and pointers in C++. |
| 4. Familiarize in structures, classes and objects of C ++. |
| 5. Write programs using C++. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Ravichandran, D. (2003).*Programming with C++*, Tata McGraw Hill Publications,Company Limited, 2nd Edition.
 |
| 1. Balagurusamy, E. (2006). *Programming with C++,* Tata McGraw Hill Publications, Company Limited, 3rd Edition.
 |
| 3. Eric Nagler. (1999).*Learning C++ Second Edition*, PWS Publishing co., Ltd., 3rd Edition.4. Robert Lafore. (2002).*Object Oriented Programming in C++,*Galgotia Pub. Pvt. Ltd, NewDelhi, 4th Edition |

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| **SEMESTER: V****PART: IV** | **22USTAS59: INDIAN OFFICIAL STATISTICS (SKILL BASED SUBJECT – III)** | **CREDIT:2****HOURS:2/week** |

**Course Objectives**

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| --- |
| 1.Understand the functioning of government and policies. |
| 2.Promote human resource development in the official statistics.3. Execute the data handling tasks in various government records.4. To encourage research anddevelopment in theoretical statistics.5. To encourage research anddevelopment in appliedstatistics. |

**Unit I: Hours: 5**

Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO).Organization of large-scale sample surveys.General and special data dissemination systems.

**Unit II: Hours:5**

Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

**Unit III: Hours:4**

System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects.

**Unit IV: Hours:5**

Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Construction of index numbers and uses.

**Unit V: Hours: 5**

National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. Measurement of income inequality: Gini’s coefficient, Lorenz curves, Application of Pareto and Lognormal as income distribution.

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Understand the fundamentals of measurement in official statistics. |
| 2.Evaluate the methods for data collection, analysis and interpretation of health, social and economic. |
| 3. Use appropriate methods for presenting and preparing commentaries on official statistics. |
| 4. Execute the tasks in agricultural and economic statistics. |
| 5. Overcome the limitations that arises from measurement and processes of statistical production. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Allen R. G. D. (1975). *Index Numbers in Theory and Practice*, Macmillan. |
| 2.C. S. O. (1990). *Basic Statistics Relating to the Indian Economy*.3. C.S.O. (1995). *Statistical System in India*.4. C. S. O. (1999). *Guide to Official Statistics*.5. Mukhopadhyay, P. (2011). *Applied Statistics*, Second Edition, Books & Allied Ltd, India.**Supplementary Readings**1. Bhaduri, A. (1990). *Macroeconomics: The Dynamics of Commodity Production*, Macmillan India Limited, New Delhi.2. Branson, W. H. (1992). *Macroeconomic Theory and Policy*, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.3. Goon A. M., Gupta M. K., and Dasgupta. B. (2001).*Fundamentals of Statistics*, Vol. 2, World Press, India.4. Panse, V. G. (1964). *Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.*5.[https://www.classcentral.com/course/swayam-macro-economics-19942](https://www.classcentral.com/course/swayam-macro-economics-19942%20). 6. <https://www.classcentral.com/course/swayam-economics-of-health-and-health-care->14023. **Outcome Mapping**

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|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 3 | 3 | 2 | 2 | 3 |
| CO2 | 3 | 3 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 3 | 2 | 2 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 3 |

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| **SEMESTER: VI****PART: III** | **22USTAC61: STATISTICAL INFERENCE II****(CORE COURSE – X)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| --- |
| 1. To give detailed idea of estimation and testing of hypothesis to the students. |
| 2. To give detailed idea about Non-Parametric Tests. |

**UnitI: Hours:10**

Testing of Hypothesis - Neyman - Pearson theory - Statistical Hypothesis - Simple and composite hypothesis, Null and Alternative Hypothesis - Two types of errors - critical region- powers of a test - Most powerful test – Neyman-Pearson lemma - simple problems.

**Unit II: Hours:10**

Uniformly most powerful tests, Likelihood ratio criterion - Definition and test for means and variance (one sample only).

**Unit III: Hours:8**

Sequential Probability Ratio Test: Definition - properties and simple problems.

**Unit IV: Hours:10**

Non-parametric tests - Run, Median, sign and Mann Whitney tests (one sample and two sample) problems. Wilcoxon Signed rank test, test sum test, Kolmogorov's Smirnov one sample test, and Kruskal Wallis test.

**Unit V: Hours:10**

Basic ideas on decision theory - Loss functions - Risk functions - Prior distributions - Bayes Risk - Simple problems based on Bayes estimation and testing.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Study about Testing of Hypothesis. |
| 2. Understand the concepts of uniformly most powerful test. |
| 3. Understand the concept of SPRT. |
| 4. Study about Non-Parametric tests. |
| 5. Understand the concept of decision theory. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Mood, A.M.,Graybill, F.A. and Boes, D.C. (1974).*Introduction to the Theory of Statistics*, McGraw Hill. |
| 2. Hogg,R.V.and Craig, A.T. (1972).*Introduction to Mathematical Statistics*, 3rd edition, Academic Press, USA. |
| 3. Goon, A.M., Gupta, M.K.and Das Gupta, B. (1980).*AnOutline of Statistical Theory*, Vol.I, 6th revised ed. World Press limited, Calcutta.4. Hod, P.G. (1971).*Introduction to Mathematical Statistics*, Asia Publishing House.5. Rohatgi, V.K. (1984).*AnIntroduction to Probability Theory and Mathematical Statistics*, WileyEastern. |

**Supplementary Readings**

|  |
| --- |
|  |
| 1. MarekFisz (1961).*ProbabilityTheory and Mathematical Statistics*, John Wiley. |
| 2. Spiegal,M.R. (1982).*Theory and Problems of Probability and Statistics*, Schaum's outline series, McGraw Hill.**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 2 | 2 | 3 | 2 | 3 |
| **CO3** | 2 | 3 | 2 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 3 | 2 | 2 |

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| **SEMESTER: VI****PART: III** | **22USTAC62: REGRESSION ANALYSIS** **(CORE COURSE – XI)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| --- |
| 1. To study the various regression models and their applications. |
| 2. To study the estimation of parameters in regression analysis |
| 3. To learn the testing of regression coefficients |

**Unit I: Hours: 8**

Simple Regression model: Description of data model – Estimation and test of hypotheses – Index of fit – Predicted values and standard errors – Evaluation of fit – Analysis of residuals.

**Unit II: Hours:10**

Simple Regression model: Effect of outliers in simple linear regression – Model adequacy and residual plots –Deletion of data points – Transformation of variables – Transformations to stabilize variance – Removal of Heteroscedasticity – Principle of weighted least squares.

**Unit III: Hours:10**

Multiple regression model: Description of data model – Properties of least square estimators – Predicted values and standard errors – Multiple correlation coefficient – Selection of variables – Forward selection procedure – Backward elimination procedure – Stepwise method (algorithms only).

**Unit IV: Hours:10**

Test of hypothesis on the linear model – Assumption about the explanatory variable – Testing a subset of regression coefficients equal to zero – Testing of equality of regression coefficients.

**Unit V: Hours: 10**

Multicollinearity and its effects on inference and forecasting – Detection of multicollinearity – Searching of linear functions of regression coefficients – Method of overcoming multicollinearity problem, Ridge method.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Fit linear regression |
| 2. Testing the regression coefficient |
| 3. Study the multiple regression analysis |
| 4. Familiarize prediction and tests in regression |
| 5. Study multicollinearity. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Chatterjee, S. and Price, B. (1977).*Regression Analysis by Example*, John Wiley & Sons, New York.  |
| 2. Draper, N.R. & Smith, H. (1981).*Applied Regression Analysis*, Second Edition. |
| 3. Gujarati, D.N. and Sangeetha, (2008).*Basic Econometrics*, (4th Edition). Tata McGraw Hill Publishing Company, New Delhi.4. Plackeff, R. L. (1960).*Principles of Regression Analysis*, Oxford at the Clavendon Press.5. Huang. D. S. (1970).*Regression and Econometric Methods*, John Wiley and Sons.  |

**Supplementary Readings**

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|  |
| 1. Brook. R. J. and Arnold. G. C. (1985).*Applied Regression Analysis and Experimental Design*, Marcel Dekker, Inc. |

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| 2. Brook. R. J. and Arnold. G. C. (1985).*Applied Regression Analysis and Experimental Design*, Marcel Dekker, Inc.**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 2 | 2 | 3 | 2 |
| **CO2** | 3 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 2 | 3 | 2 |
| **CO5** | 3 | 2 | 3 | 2 | 3 |

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| **SEMESTER: VI****PART: III** | **22USTAC63: DESIGN OF EXPERIMENTS****(CORE COURSE – XII)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| --- |
| 1. To enable the students to learn basic concepts of design and its applications. |
| 2. To have practical knowledge on the applications of designs in agriculture data. |

**Unit I: Hours: 10**

Fundamental Principles of Experiments – Replication, Randomization and Local Control techniques – Size of experimental unit – Methods of determination of experimental units – (Maximum curvature method – Fairfield Smith’s variance law).

**Unit II: Hours:10**

Analysis of Variance and Basic Designs: One-Way and Two-Way analysis of variance. Principles of Design of Experiments - Completely Randomized Design and its analysis – Randomized Block Design and its analysis – Latin Square Design and its analysis.

**Unit III: Hours:8**

Post ANOVA Tests: Multiple range test; Newman-Keul’s test – Duncan’s multiple range test – Tukey’s test – Transformation – Square root, angular and log transformations.

**Unit IV: Hours:10**

Missing plot techniques – Meaning – Least Square method of estimating one missing observation – RBD and LSD – Two observations missing in RBD and LSD – Analysis of covariance technique in CRD and RBD (without derivation).

**Unit V: Hours: 10**

Factorial experiments – Definition – 2 2 , 23 and 32 factorial experiments and their analysis – Principles of confounding – Partial and complete confounding in 23 – Split plot design and its analysis.

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Understand the basic concepts of experimental designs. |
| 2. Study the various basic designs. |
| 3. Understand the use of various multiple comparison tests. |
| 4. Study the missing plot techniques of basic designs. |
| 5. Study the factorial experiments and confounding. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Das, M.N. and Giri, N.C. (1986).*Design and Analysis of Experiments*, Wiley Eastern, New Delhi. |
| 2. Montgomery, D. (1972).*Design of Experiments*, Wiley, New York. |
| 3. Kapoor, V.K. and Gupta, S.P. (1978).*Fundamentals of Applied Statistics*, Sultan Chand & Sons, New Delhi.4. Dean, A. and Voss.(2006). *Design and Analysis of Experiments*, Springer, New Delhi.**Supplementary Readings**

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|  |
|  1. Dey, A. (1986).*Theory of Block Designs*, Wiley, New York. |

**Outcome Mapping**

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 3 | 3 |

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| **SEMESTER: VI****PART: III** | **22USTAC64: STOCHASTIC PROCESSES****(CORE COURSE – XII)** | **CREDIT:4****HOURS:4/week** |

**Course Objectives**

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| --- |
| 1. To acquire the standard concepts and methods of Stochastic Modelling and applications. |
| 2. To study the applications of Markov chains |
| 3. To study the practical usages of various random processes |

**Unit I: Hours: 10**

Basic Concepts: Definition and examples of stochastic process, classification of general stochastic processes into discrete and continuous time, discrete and continuous state spaces, types of stochastic processes, elementary problems.

**Unit II: Hours:10**

Markov chains: Definition and examples of Markov chain, Transition Probability Matrix, classification of states, recurrence, simple problems.

**Unit III: Hours:8**

Basic limit theorem of Markov chain (statement only), stationary probability distribution, applications.

**Unit IV: Hours:10**

Continuous Time Markov chain: Pure birth process and Poisson process, Birth and Death process, problems.

**Unit V: Hours: 10**

Branching process: Definition and examples of discrete time branching process, probability generating function, mean and variance, probability of extinction, simple problems.

**Course Outcomes**

At the end of the course, the student will be able to:

|  |
| --- |
| 1. Understand the basic concepts and classifications of stochastic processes. |
| 2. Study the theorems of stationary probability distributions. |
| 3. Analyse the birth and death processes and their applications. |
| 4. Study the branching processes and their related concepts. |
| 5. Apply and analyse the various queueing systems in real life situations. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Medhi, J. (2015).*Stochastic Processes* Third Edition, Wiley Eastern Limited, New Delhi. |
| 2.Karlin, S and Taylor, H.W. (1975).*A First course in Stochastic Processes*, Academic press, 2nd edition. |
| 3. Karlin, S and Taylor, H.W. (1979).*A Second Course in Stochastic Processes*, Academic Press.4. Prabhu, N.U. (1965).*StochasticProcesses*, McMillan.5. Bharucha Reid,A.T, (1960).*Markov Chain with Applications*. John Wiley, New York. |

**Supplementary Readings**

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| --- |
|  |
| 1. Parzen, E. (1962).*StochasticProcesses*, Holden-Day. |
| 2. Hoel, P.M.G., Port, S.C. and Stone, C.J. (1991).*Introduction to Stochastic Processes*, Universal Book Stall. |

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 2 |

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| --- | --- | --- |
| **SEMESTER: VI****PART: III** | **22USTAP65: STATISTICAL PRACTICAL – III** **(CORE PRACTICAL – III)** | **CREDIT:****HOURS:** |

**Course Objectives**

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| --- |
|  1. To enable students to solve problems related to estimation and hypothesis testing, statistical quality control techniques and design and analysis of experiments |

**Practical Schedule: -**

Problems relating to the following topics which are covered in Semester V and Semester
VI shall form the basis for practical:

**1. Estimation theory** (problems related to estimation of parameters under various methods, confidence intervals for mean, variance and proportions)

**2. Statistical Quality Control** (Control charts for variables and attributes).

**3. Testing of Statistical Hypotheses** (problem related to test of significance of mean, variances, one sample, two samples and more than two samples, non-parametric tests)

**4. Design and Analysis ofExperiments**(problem related to CRD, RBD, LSD, Missing Plot Techniques, Factorial experiments 22, 23, 32)

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note:**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Practical-III shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test (25 marks) and record work (15 marks). The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 mark

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 2 | 2 |

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| **SEMESTER: VI****PART: III** | **22USTAP66: STATISTICAL DATA ANALYSIS- SOFTWARE BASED (CORE PRACTICAL – IV)** | **CREDIT:****HOURS:** |

**Course Objectives**

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| --- |
| 1.To enable students to utilize the theoretical knowledge gained in the core papers and to  develop computational and technical skills for real life applications emphasizing the importance of statistical software programming. |

**Practical Schedule: -**

To compute the various statistical measures using statistical software SPSS.

1. Tabulation and diagrammatical representation of data.

2. Measures of Central Tendency, Dispersion, Skewness and Kurtosis

3. Correlation and Regression, simple and multiple linear regression.

4. Parametric tests: t-test, F-test, chi-square test.

5. Analysis of variance: One-way Classification, Two-way Classification.

6. Non-Parametric Tests: Sign test, Wilcoxon test, Mann-Whitney U test, Median test, Run test,

Kolmogorov Smirnov test, Kruskal Wallis test.

7. Statistical Quality control charts for variables

8. Statistical Quality control charts for attributes

**Text Books**

Books prescribed in the respective core papers shall be used.

**Note**

The maximum marks for continuous internal assessment and end semester University examination for Statistical Data Analysis-II shall be fixed as 40 and 60, respectively. The continuous internal assessment shall involve test and record work. The question paper at the end semester examination shall consist of **four questions with internal choice**. A candidate shall attend all the four questions, each of which shall carry 15 marks.

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 2 | 2 | 3 | 2 |
| **CO4** | 3 | 2 | 3 | 2 | 3 |
| **CO5** | 3 | 2 | 3 | 2 | 3 |

**INTERNAL ELECTIVE– IV**

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| **SEMESTER: VI****PART: III** | **22USTAE68-1: DEMOGRAPHY** | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1.To acquire the knowledge of demographic methods applicable to statistical data analysis.2. To have knowledge on Mortality and Morbidity and life table. |

**Unit I: Unit Title Hours: 7**

Definition of Demography.PopulationChange.Size and Structure of Population.Components of Population Change.DemographicData.Sources of Demographic Data.Balancing Equation and Age-Sex Pyramids.

**Unit II: Unit Title Hours:7**

Fertility and Reproduction.Period Measures of Fertility and Reproduction.Cohort Measures of Fertility and Reproduction.Fertility Transition and Replacement Level of Fertility.Population Momentum.

**Unit III: Unit Title Hours:7**

Mortality and Morbidity.Period Measures of Mortality and Morbidity.Cohort Measures of Mortality and Morbidity.Lexis Diagram and its importance in Mortality Analysis.Force of Mortality.

**Unit IV: Unit Title Hours:7**

Life Table.Cohort Life Table and Period Life Table. Complete Life Table and Abridged Life Table. Different Methods of Construction of Complete Life Table and Abridged Life Table.

**Unit V: Unit Title Hours: 8**

Migration.Different Forms of Migration. Measures of Migration: Migration Rates and Ratios. Migration Streams and Counter Streams.Index of Redistribution.Indices of Migration differentials and selectivity.Index of Preference.

**Course Outcomes**

 At the end of the course, the student will be able to:

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| --- |
| 1. Understand the basic concepts of demography. |
| 2. Study the area of fertility. |
| 3. Have thorough knowledge mortality and morbidity. |
| 4. Understand the use of life table |
| 5. Have idea on migration concepts. |

**Text Books (In API Style)**

|  |
| --- |
| 1. Ramakumar, R. (1986).*Technical Demography*. |
| 2. Pathak, K.B. & Ram, F. (2005).*The Techniques of Demographic Analysis*.3. Misra, B.D. (1980).*The Study of Population*.4. United Nations (1952). Manual I- *Methods of Estimating Total Population for Current Dates*.5. Srinivasan, K. (1998). *Basic Demographic Techniques and Applications*.6. United Nations (1967). Manual IV- *Methods of Estimating Basic Demographic Measures from Incomplete Data*.7. United Nations (1970). Manual VI- *Methods of Measuring Internal Migration.* |

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 2 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 3 | 2 | 3 | 2 |

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| **SEMESTER: VI****PART:** | **22USTAE68-2: REAL ANALYSIS II**  | **CREDIT:3****HOURS:3/week** |

**Course Objectives**

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| 1.To make the students get understanding Riemann Integration, convergence and metric space.2.To gain knowledge about improper integrals3. Able to understand series of functions and applications |

**Objective:**

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**UNIT – I**

Riemann Integration : Definition of the Riemann Integral Existence of the Riemann Integral Properties of the Riemann Integral - Fundamental theorems of Calculus -Mean Value Theorems.

**UNIT – II**

Improper Integrals their convergence and evaluation, convergence of Beta and Gamma integrals

**UNIT – III**

Sequences of Functions: Point wise convergence of Sequences of functions Uniform convergence of Sequences of functions Consequences of Uniform Convergence Properties without proof.

**UNIT – IV**

Series of Functions: Convergence and uniform convergence of series of functions. Weisstrass test - Integration and differentiation of series of Functions Abel Summability.(without proof) - Application

**UNIT – V**

Metric Space definitions and examples, continuous functions on metric spaces Open sets, closed sets and closure properties.

**Course Outcomes**

 At the end of the course, the student will be able to:

1.understand Riemann Integration

2. understand the Improper Integrals their convergence

3.apply Abel summability , Weisstrass test

**Books for Study**:

1. D. Somasundaram and B. Choudhary (2002) : A first course in Mathematical Analysis, Narosa Publishing house

2. R. R. Goldberg ( 1970) : Methods of Real Analysis, Oxford & IBH.

**Books for Reference:**

1. T. M. Apostol(1985) : Mathematical Analysis, Narosa Publishing House 2. W. Rudin(1976): Principles of Mathematical Analysis, 3/e, McGraw Hill Company.

**Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 3 |
| **CO5** | 3 | 3 | 2 | 3 | 3 |

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| **SEMESTER: VI****PART: IV** | **22USTAS69: ECONOMETRICS (SKILL BASED SUBJECT – IV)** | **CREDIT:****HOURS:** |

**Course Objectives**

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| 1. To enrich the skills of students to understand the nature and functioning of economic systems. |
| 2. To know the practical applications of auto correlation and multicollinearity. |

**Unit I: Hours:**

Model with one explanatory variable: Definition, scope and objectives of Econometrics. Linear model with one independent variable - Least squares estimators of regression coefficients, properties of least squares estimators - analysis of variance to regression model.

**Unit II: Hours:**

Model with more variables: Linear model with more than one explanatory variables – assumptions – estimation of model parameter - Least squares estimators and their properties. Hypothesis testing – test the overall significance of the regression – Testing the individual regression coefficients.

**Unit III: Hours:**

Adequacy of Model: Model adequacy checking – residual analysis – residuals – standardized residuals – residual plot – normal probability plot – plot of residuals against estimated response. A formal test for lack of fit of the model.

**Unit IV: Hours:**

Autocorrelation: Meaning of serial independence – sources of autocorrelation – first order autoregressive scheme – consequences of autocorrelation – Durbin – Watson test – analyzing the model in the presence of autocorrelation.

**Unit V: Hours:**

Multicollinearity: Meaning and sources – consequences of multicollinearity. Test for detecting multicollinearity – Examining the correlation matrix – Variance Inflation factor – Eigen values of X X.

**Course Outcomes**

At the end of the course, the student will be able to:

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| --- |
| 1. Understand the basic concepts of econometric models. |
| 2. Study the linear model. |
| 3. Study the adequacy and checking of models. |
| 4. Study the concept of autocorrelation and their tests. |
| 5. Study the concept of multicollinearity. |

**Text Books (In API Style)**

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| --- |
| 1. Montgomery, D.C., Peck, E.C. and Vining, G.G. (2003).*Introduction to Linear Regression Analysis (3/e)*, Wiley Eastern, New Delhi. |
| 2.Koutsoyiannis, A. (2006).*Theory of Econometrics,* (2/e) Palgrave, New York. |
| 3. Singh, S. P., Parashar, K. and Singh, H. P. (1980).*Econometrics*. Sultan Chand &Co., New Delhi.4. Klein, L. R. (1975).*A Text Book of Econometrics (2/e)*. Prentice Hall,New Delhi.5. Johnston, J. (1984).*Econometric Methods*, McGraw Hill Pvt. Ltd., New Delhi, |

**Supplementary Readings**

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|  |
| 1. Gujarati, D.N.&Sangeetha, (2008).*Basic Econometrics*, McGraw Hill, New York. |
| **Outcome Mapping**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 2 | 3 | 2 | 2 | 3 |
| **CO5** | 2 | 3 | 3 | 2 | 3 |

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| SEMESTER:IIPART:III | 22USMAA02 : STATISTICAL METHODS AND THEIR APPLICATIONS | CREDIT: 3HOURS: 4 |

(For BCA)

COURSE OBJECTIVES

1. To know about statistics
2. To know about measurs of centeal tendencies and dispersion
3. To know about correlation and regression
4. To know the concept of probability and distribution
5. To apply test of significance

UNIT I : Introduction to statistics Hours: 10

Statistics, functions, characteristics, limitations.Various types of Data; Nominal, Ordinal, Ratio Scale and Interval; Primary and Secondary Data; Methods of Collecting Primary Data;Diagrammatic and Graphical representation of data. - sample and Population-Preparation of questionnaire.

UNIT II:measures of central tendencies and dispersion Hours: 10

Descriptive Measures – Mean, Median, Mode;geometric and harmonic ,positional averages, range,Quartile deviation Mean Deviation and Standard Deviation.

 UNIT III: correlation and regression Hours:10

Study of relationship between variables: Concept of correlation- types of correlation, rank correlation and simple problems. Regression Analysis: Simple Regression Equations.

UNIT IV: Probability and random variables Hours:10

Probability Theory: definitions- axioms of probability; simple problems -addition and multiplication theorem - Baye’s theorem–simple problems, types of random variables, Binomial, Poisson and Normal

UNIT V: tests of significance Hours:10

Test of significance: small sample t-test (mean, SD, Correlation), F test for variance–large sample z-test (mean and proportions)- chi square test-simple problems

COURSE OUTCOMES

1. At the end of the course, the student will be able to:
2. Understand the various concepts of statistics.
3. know about measures of centeal tendencies and dispersion
4. know the concept of correlation and regression
5. apply the concept of probability distribytion
6. test the population parametric value

Text Books

1. Gupta,S.P.: , Sultan Chand& Sons Pvt Ltd ,”Statistical Methods.”New Delhi.
2. Rajagopalan V., (2006), New Age International Publishers (P) Ltd, ”Selected Statistical Tests”.., New Delhi.

OUTCOME MAPPING

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 1 | 3 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 2 | 2 |
| CO5 | 1 | 3 | 3 | 3 | 3 |

1 – Low, 2 – Moderate, 3 – High (Preferably use 2 or 3 levels)