# DEPARTMENT OF STATISTICS

## SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)

## (FIRST – EIGHT SEMESTER)

**Approved by Academic Council vide Resolution no. AC – 03/2024/05 dated: 04 – 05– 2024 and AC – 06/2026/03 dated 28 – 02 - 2026**

## ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)

ARYA NAGAR, GUWAHATI – 16

# CONTENT

# PREFACE

**"Education is not preparation for life; education is life itself." — John Dewey**

The aim of imparting education is not only to increase the knowledge but also to create the possibilities for a student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) -the spirit of NEP, 2020. The programmes offered by the college are:

i. Bachelor Degree in Arts
ii. Bachelor Degree in Science
iii. Bachelor Degree in Commerce

Under the above programme, the following courses are offered by the college:

i. Core Course
ii. Minor Course
iii. Skill Enhancement Course
iv. Interdisciplinary Course
v. Ability Enhancement Course
vi. Value Added Course
vii. Internship

Programme outcome of each programme and Programme Specific Outcomes of each discipline/subject offered by the college is mapped with course learning outcome of each course. Graduate attributes of students obtaining Undergraduate Degree from the college are also incorporated in the syllabus.

The syllabus includes eight semesters where there will be 23 Core Courses, 8 Minor Courses, 2 Value Added Courses, 3 SEC Courses, 3 IDC Courses, 4 AEC courses and internship. The total credit offered for eight semesters is160.

The syllabus framed takes into account the different styles of learning – audio, visual and experiential. The syllabus correlates academics to real life situations balancing social and emotional stimulation among the students and imbibe human values. Also, the syllabus gives the opportunity for the theoretical knowledge to be pursued ensuring maximum application of it.

## Structure of Four Year Undergraduate Course

| Semester | Type | Core | Minor | SEC | IDC | AEC | VAC/FC | IN |
|---|---|---|---|---|---|---|---|---|
| | Credit | 4 | 4 | 3 | 3 | 2 | 4(2 + 2) | 2 |
| I | | CE-1114 | MN-1114 | SE-1113 | ID-1113 | AE-1112 | VL-1112 (Two Courses) | - |
| II | | CE-2114 | MN-2114 | SE-2113 | ID-2113 | AE-2112 | VL-2112 (Two Courses) | - |
| III | | CE-3214 | MN-3214 | SE-3213 | ID-3213 | AE-3212 | - | - |
| | | CE-3224 | | | | | | |
| IV | | CE-4214 | MN-4214 | - | - | AE-4212 | - | IN-4212 |
| | | CE-4224 | | | | | | |
| | | CE-4234 | | | | | | |
| V | | CE-5314 | MN-5214 | - | - | - | - | - |
| | | CE-5324 | | | | | | |
| | | CE-5334 | | | | | | |
| | | CE-5344 | | | | | | |
| VI | | CE-6314 | MN-6214 | - | - | - | - | - |
| | | CE-6324 | | | | | | |
| | | CE-6334 | | | | | | |
| | | CE-6344 | | | | | | |
| VII | | CE-7414* | MN-7314 | - | - | - | - | - |
| | | CE-7424** | | | | | | |
| | | CE-7434** | | | | | | |
| | | CE-7444** | | | | | | |
| | | CE-7454** | | | | | | |
| VIII | | CE-8414# | MN-8314 | - | - | - | - | - |
| | | CE-8424# | | | | | | |
| | | CE-8434# | | | | | | |
| | | CE-8444# | | | | | | |
| | | CE-8454# | | | | | | |

***Compulsory for all students in the 7th semester.**

****Students are required to choose any three courses from the remaining four core courses in the 7th semesters.**

**# Students who wish to pursue a Bachelor Degree with Honours must choose any four of the five core courses in the 8th semester.**

**NOTE: Students who secure a minimum of 7.5 CGPA at the end of the 6th semester (without any arrears) may opt for a Bachelor Degree with Honours and Research. Those students shall have to choose one core course out of the given five courses in the 8th semester and have to complete a Research Dissertation of 12 credits.**

**Course code:** **First two letters is the abbreviation of course component**

**First digit implies semester number**

**Second digit implies course level**

**Third digit implies course number**

**Fourth digit implies credit points per course.**

| Digit | Course Level |
|---|---|
| 1 | 100 - 199 |
| 2 | 200 - 299 |
| 3 | 300 - 399 |
| 4 | 400 - 499 |

**Semester Wise Credit Distribution**

| Semester | CREDIT DISTRIBUTION | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CORE | MINOR | SEC | AEC | IDC | VAC/FC | IN | TOTAL |
| FIRST | 1 x 4 | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | 2x 2 | -- | 20 |
| SECOND | 1 x 4 | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | 2x 2 | -- | 20 |
| THIRD | 2x 4 | 1 x 4 | 1 x 3 | 1 x 2 | 1 x 3 | -- | -- | 20 |
| FOURTH | 3x 4 | 1 x 4 | -- | 1 x 2 | -- | -- | 1 x 2 | 20 |
| FIFTH | 4x 4 | 1 x 4 | -- | -- | -- | -- | -- | 20 |
| SIXTH | 4x 4 | 1 x 4 | -- | -- | -- | -- | -- | 20 |
| SEVENTH | 4x 4 | 1 x 4 | -- | -- | -- | -- | -- | 20 |
| EIGHT | 4x 4 | 1 x 4 | -- | -- | -- | -- | -- | 20 |

**SEC: SKILL ENHANCEMENT COURSE**

**AEC: ABILITY ENHANCEMENT COURSE**

**IDC: INTERDISCIPLINARY COURSE**

**VAC/FC: VALUE ADDED COURSE**

**IN: INTERNSHIP**

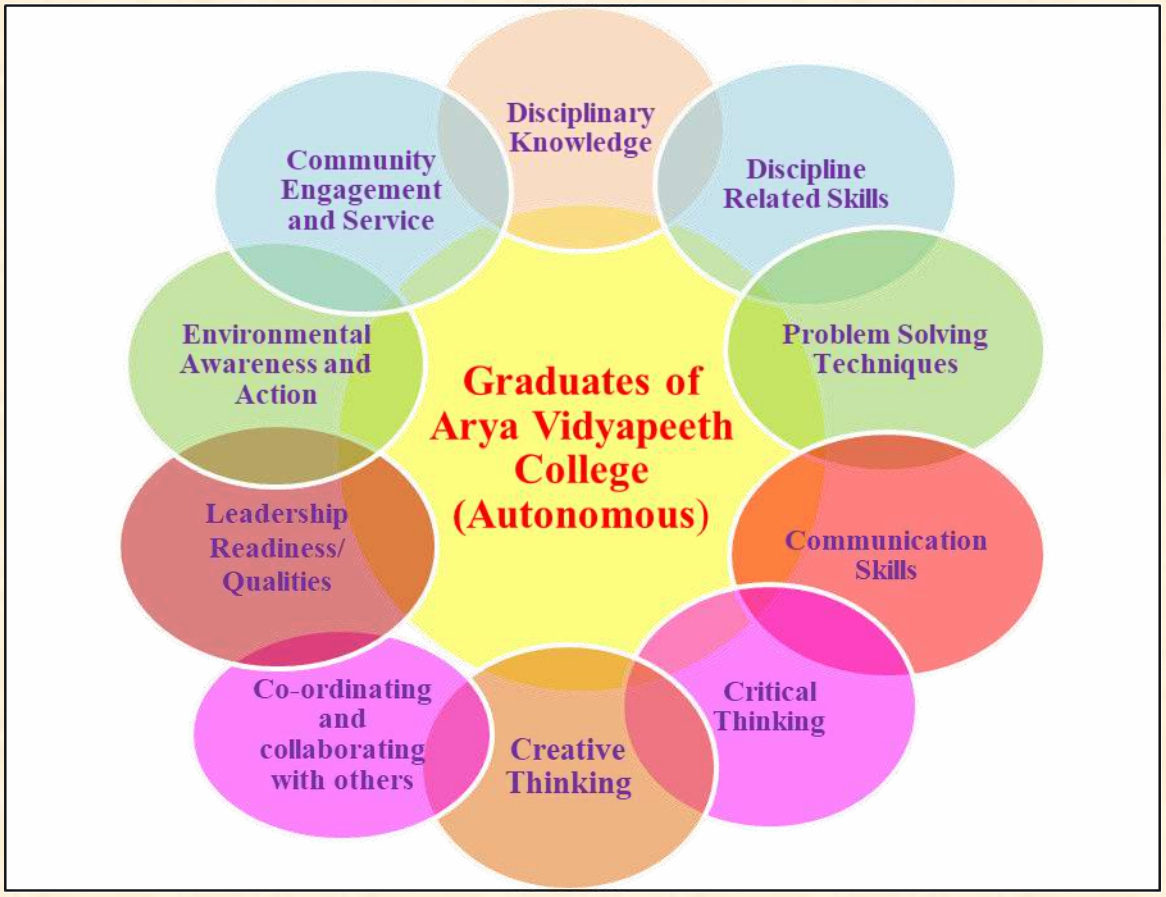
**Abbreviation of Course Components:**

**CE (Core), MN (Minor), SE (Skill Enhancement Course), AE (Ability Enhancement Course), VL (Value added Course), ID (Interdisciplinary Course), IN (Internship)**

# GRADUATE ATTRIBUTES

**Graduate Attributes:**

Graduate Attributes are the qualities, skills and understandings that the students should develop during their time with the college. These attributes consequently shape the contribution they are able to make to their profession and society. They are the qualities that also prepare graduates as agents of social good in an unknown future. These attributes set them apart from those without a degree. The graduate attributes of Arya Vidyapeeth College (Autonomous) are:




**Model of Graduate Attributes**

1. **Disciplinary knowledge:** Graduates shall acquire comprehensive knowledge and understanding of their subject area, the ability to engage with different traditions of thought, and the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
2. **Discipline related skills:** Skills in areas related to specialization in the chosen disciplinary/interdisciplinary/major/minor area(s) of learning in a broad multidisciplinary context. In addition, create, select, and apply appropriate modern techniques, resources and IT tools.
3. **Problem solving skills:** A capacity for problem identification, the collection of evidence, synthesis and dispassionate analysis and apply one's learning in real – life situations.

4. **Communication Skills:** Ability to recognize and value communication as the tool for negotiating and creating new understanding, collaborating with others, and furthering their own learning.
5. **Critical thinking:** Graduates acquire the capacity for problem identification, collection of evidence, synthesis and dispassionate analysis. They also acquire the capacity for attentive exchange, informed argument and reasoning.
6. **Creative Thinking:** The graduates acquire an ability to create, perform or think in different and diverse ways about the same objects or scenarios and also the ability to communicate effectively for different purposes and in different contexts. They should also be able to work independently and as part of a team.
7. **Co-ordinating and collaborating with others:** The graduates need to possess the ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. They should also be able to work productively with others, no matter their culture, perspective or background, and complete joint projects and also to work in partnership.
8. **Leadership readiness/qualities:** The graduates should be able to lead and support others by inspiring them with a clear vision and motivating them to achieve goals. They also need to acquire ability to map out the tasks of a team or an organization and setting directions.
9. **Environmental Awareness and action:** The graduates shall earn the capacity to realize the individual's responsibility in protecting and conserving the environment. They need to gain the capacity to understand the impact of the professional solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
10. **Community engagement and service:** The graduates need to develop an understanding of social and civic responsibilities, and of the rights of individuals and groups. The graduates should be able to demonstrate the capability to participate in community-engaged services/ activities for promoting the wellbeing of the society which includes participation in NSS, NCC, adult literacy etc

# UNDERGRADUATE PROGRAMME OUTCOME (PO)

## BACHELOR DEGREE IN SCIENCE: (B.Sc.)

1. **SPO-1 Knowledge:** Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.
2. **SPO-2 Problem Analyses**: Well, equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyse results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyse scientific problems and reach concrete solutions using various principles of mathematics and sciences.
3. **SPO-3 Designing Solutions**: Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.
4. **SPO-4 Modern tool usage**: Learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).
5. **SPO-5 Effective Communication**: Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.
6. **SPO-6 Employability**: This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations
7. **SPO-7 Ethics:** While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economic and environmental issues. One of the main objectives of any academic

exercise, therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As such, at the end of this programme students will be able to develop, internalise and exercise ethics in their professional as well as personal practices.

8. **SPO-8 Environment and Sustainability**: 'Environmental sustainability' has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyse socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.

9. **SPO-9 Soft-Skill Development**: Apart from the attainment of knowledge and hands on skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.

10. **SPO-10 Science and Society**: The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.

11. **SPO-11 Life-long learning**: With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self-motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

# CORE

## LIST OF COURSES:

| Semester | Course Name | Course Code |
|---|---|---|
| 1 | Statistical Methods I | ST – CE – 1114 |
| 2 | Basic Probability Theory | ST – CE – 2114 |
| 3 | Statistical Methods II | ST – CE – 3214 |
| | Calculus | ST – CE – 3224 |
| 4 | Algebra | ST – CE – 4214 |
| | Theory of Probability Distributions | ST – CE – 4224 |
| | Applied Statistics I | ST – CE – 4234 |
| 5 | Mathematical Analysis | ST – CE – 5314 |
| | Sampling Distributions | ST – CE – 5324 |
| | Statistical Inference I | ST – CE – 5334 |
| | Survey Sampling and Indian Official Statistics | ST – CE – 5344 |
| 6 | Operations Research | ST – CE – 6314 |
| | Analysis of Variance and Design of Experiment | ST – CE – 6324 |
| | Statistical Inference II | ST – CE – 6334 |
| | Multivariate Analysis and Non Parametric Tests | ST – CE – 6344 |

| Semester | Course Name | Course Code |
|---|---|---|
| 7 | **GROUP-A*** | |
| | Research Methodology | ST–CE–7414 |
| | **GROUP-B*** | |
| | Stochastic Process and Queueing Theory | ST–CE–7424 |
| | Applied Statistics II | ST–CE–7434 |
| | Advanced Multivariate Analysis | ST–CE–7444 |
| | Measure Theory and Probability | ST–CE–7454 |
| 8 | **GROUP-A*** | |
| | Statistical Computing with C and Python | ST–CE–8414 |
| | **GROUP-B*** | |
| | Linear Algebra | ST–CE–8424** |
| | Econometrics | ST–CE–8434** |
| | Bio Statistics and Survival Analysis | ST–CE–8444** |
| | Distribution Theory and Simulation | ST–CE–8454** |
| | Dissertation | ST-DT-812** |

*Students have to select any three courses (papers) from Group-B and the compulsory course (paper) in Group-A

**Students who secure more than 7.5 CGPA at the end of third year ($6^{th}$ semester), may opt for a research dissertation of 12 credits instead of the three core papers.

**Programme Specific Outcome of Bachelor of Science-Statistics Core (PSO)**

| PSO No. | Name | Outcome |
|---|---|---|
| PSO–1 | Knowledge and understanding | This course is expected to provide strong foundation Knowledge and understanding of statistics. |
| PSO–2 | Designing Solution | This course helps the students to acquire knowledge of Statistics and trained them to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved. |
| PSO–3 | 21st Century skills | This course helps the students to develop the ability to bring in new ideas, research findings in the areas of real world situations. |
| PSO–4 | Analysis | At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and Statistics. |
| PSO–5 | Applicability in Real World Problem | This course exposes the students to the world of Statistics and its applications in our daily life. |
| PSO–6 | Skill Development | Exposure to a lot of real life data helps in honing their analyzing skills. Moreover, introduction to computer soft - wares helps the students to develop the skills in handling of data by making optimum usage of time and resources. These soft-wares give them the necessary support and an edge when progressing to their professional careers. |
| PSO–7 | Employability | The structure of the course is designed in such a way that it goes a long way in giving students the required impetus and confidence for consultancy startups/jobs in near future. This programme also enables the learners to perform the jobs in diverse fields such as industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations. |

**Course Learning Outcome (CLO) – Core**

| Semester | Course Name & Code | Course Learning Outcome (CLO) | |
|---|---|---|---|
| 1 | Statistical Methods I<br>ST – CE – 1114 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of statistical population and sample, variables and different scales of measurements. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of diagrammatic and graphical presentation of data. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of measures of central tendency, dispersion, moments, skewness and kurtosis. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of interpolation techniques and numerical integration. |
| | | CLO - 5 | After completing this course, students should have developed a clear understanding of correlation and regression. |
| 2 | Basic Probability Theory<br>ST – CE – 2114 | CLO - 1 | After completing this course, students should have developed a clear understanding of basic probability theory, random experiment, algebra of events, theorems and laws of probability |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of random variables, their expectations, moments, generating functions and probability functions. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of probability inequalities, laws of convergence and applications of law of large numbers. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of Important discrete and continuous probability distributions. |
| 3 | Statistical Methods II<br>ST-CE-3214 | CLO - 1 | After completing this course, students should have developed a clear understanding of fitting of linear and nonlinear curve and orthogonal polynomial using data related to real world |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of Bi-variate and Multivariate data and significance of various coefficients of correlation |

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| 3 | Statistical Methods II<br>ST-CE-3214 | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of linear model, Simple regression model, Estimation of parameters and Hypothesis testing in case of simple regression models. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of consistency, association and independence of attributes |
| | Calculus<br>ST-CE-3224 | CLO - 1 | After completing this course, students should have developed a clear understanding of concept of differential calculus, Integral calculus and their applications |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concept of differential equations, Partial Differential Equations and their applications. |
| 4 | Algebra<br>ST-CE-4214 | CLO - 1 | After completing this course, students should have developed a clear understanding of concept of theory of equations and vector space |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concept of different types of Matrices and inverse of matrix |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of Determinants of Matrices and solution to the system of linear equations |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of Rank of matrices, Characteristic roots, Characteristic vector and Quadratic forms of matrices |
| | Theory of Probability distributions<br>ST-CE-4224 | CLO - 1 | After completing this course, students should have developed a clear understanding of concept of two-dimensional random variables along with their joint, marginal and conditional p.m.f, p.d.f., and c.d.f. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of cumulant generating function, characteristic function and Probability generating |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of some important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hypergeometric and their interrelations. |

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| 4 | Theory of Probability distributions<br>ST-CE-4224 | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of some important continuous distributions such as Uniform, Normal, Exponential, Lognormal, Laplace, Weibull, Gamma, Beta and Cauchy distributions. |
| | Applied Statistics I<br>ST-CE-4234 | CLO - 1 | After completing this course, students should have developed a clear understanding of knowledge of demographic data, Population composition and dependency ratio |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of measurement of population, Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. Concept of complete life table and abridge life table |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of CBR, GFR), SFR, TFR, Crude rates of natural increase, Pearl's Vital Index, GRR) and NRR |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of index numbers and use of index numbers to real world problem. |
| 5 | Mathematical Analysis<br>ST-CE-5314 | CLO - 1 | After completing this course, students should have developed a clear understanding of concept of Real Analysis |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of infinite series |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of Limits, Continuity and Differentiability of functions |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of finite differences, interpolation and numerical integration |
| | Sampling Distributions<br>ST-CE-5324 | CLO - 1 | After completing this course, students should have developed a clear understanding of distribution of ordered statistics and their applications |

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| 5 | Sampling Distributions<br>ST-CE-5324 | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of sampling distribution of statistic and large sample test i.e. Z test for proportion, mean and standard deviation for single samples well as two samples cases. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of chi square distribution, its properties and applications. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of t,F distributions, their properties and applications. |
| | Statistical Inference I<br>ST-CE-5334 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of Estimation and its characteristics namely unbiasedness, sufficiency, consistency and efficiency. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of Minimum variance unbiased estimators and MVB estimators |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of methods of estimation namely Method of moments, method of maximum likelihood estimation and method of minimum Chi-square |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of interval estimation |
| | Survey Sampling and Indian Official Statistics<br>ST-CE-5344 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of non-probability and probability sampling, simple random sampling with and without replacement, procedure of selecting a sample and estimation of population mean, total and proportion in SRS |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of stratified random sampling and Systematic Sampling along with estimation of population mean and total in these methods, Brief idea about PPS sampling and two stage sampling |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of Ratio and Regression Method of Sampling, Cluster sampling and sub sampling |

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| | Survey Sampling and Indian Official Statistics ST-CE-5344 | CLO - 4 | After completing this course, students should have developed a clear understanding of knowledge about Indian official Statistics |
| 6 | Operations Research ST-CE-6314 | CLO - 1 | After completing this course, students should have developed a clear understanding of various types of Operations Research problems, Mathematical formulation of LPP, graphical solutions of a L.P.P and Simplex method for solving L.P.P |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of transportation Problems and initial solution by North West corner rule, least cost method and Vogel's approximation method (VAM). |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of game theory, rectangular game and minimax-maximax principle |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of inventory Management, ABC inventory system, EOQ Model and Quantity Discount Model with price breaks. |
| | Analysis of Variance and Design of Experiment ST-CE-6324 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data as well as two-way classified data for fixed effect models. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of Basic designs namely Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) along with their layouts, models and statistical analyses. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concepts of analysis of $2^2$, $2^3$…and $2^n$ factorial experiments along with total and partial confounding |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of ideas of Split plot, strip plot design and BIBD |
| | Statistical Inference II ST-CE-6334 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of simple and composite hypotheses, Non randomized test and randomized test and best critical region |

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| 6 | Statistical Inference II<br>ST-CE-6334 | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of Most powerful test, uniformly most powerful test, unbiased test and Neyman Pearson Lemma to construct most powerful test. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of• concepts and applications of Likelihood ratio test |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of ideas of Sequential probability ratio test (SPRT) and Wald's sequential probability ratio test. |
| | Multivariate Analysis and Non-Parametric Tests<br>ST-CE-6344 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of Bivariate Normal distribution, p.d.f., its properties, marginal and conditional p.d.f.. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of Probability mass/density functions of random vector, its Mean vector & Dispersion matrix, Marginal & Conditional distributions. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concepts of Multivariate normal distribution, Multiple and partial correlation coefficient and Hotelling $T^2$ |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concepts of Principle component analysis, Discriminant analysis. |
| 7 | Research Methodology<br>ST – CE – 7414 | CLO - 1 | After completing this course, students should have developed a clear understanding of the key research concepts and application of appropriate research methods. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of collection, analysis, and interpretation of data using suitable tools and techniques. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of ICT platforms, online databases, and digital tools for effective research work. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of preparation of well-structured research reports and delivery of scientific presentations confidently. |

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| | | CLO - 5 | After completing this course, students should have developed a clear understanding of understanding of intellectual property rights, cyber laws, and ethical research practices. |
| 7 | Stochastic Process and Queuing Theory<br>ST - CE – 7424 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of Stochastic processes along with its specifications and Stationary Processes. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of Markov Chain, transition probability matrix, order of Markov chain, higher transition probabilities, classification of states and chains. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concepts of Poisson Process along with its properties, inter-arrival time, generalization of Poisson Process and Birth- Death process. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of Queuing theory, M/M/1 queuing model with finite and infinite system capacity. |
| | Applied Statistics II<br>ST - CE - 7434 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts and application of time series from various fields, Components of times series, Decomposition of time series, estimation of trend and seasonal component. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts of exponential smoothing methods, Stationary and non-stationary time series, ARMA and ARIMA models. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concepts of control charts for variables and attributes. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concepts of single and double sampling plan. |
| | Advanced Multivariate Analysis<br>ST-CE-7444 | CLO - 1 | After completing this course, students should have developed a clear understanding of the basic concepts associated with Multivariate normal distributions and their properties. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of techniques for analysing multivariate data like MANOVA. |

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| | | CLO - 3 | After completing this course, students should have developed a clear understanding of analysing Multivariate data using data reduction techniques like Principal Component Analysis, Canonical Correlation Analysis, Idea of Factor Analysis. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of classification method namely discriminant Analysis. |
| | Measure Theory and Probability ST-CE-7454 | CLO - 1 | After completing this course, students should have developed a clear understanding of probability measure, properties of a measure, Lebesgue-Stieltjes measure. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of outer measure, class of outer measurable sets in a Sigma field. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of moment inequalities, Characteristic functions, continuity theorems, Modes of convergence and their interrelations. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of Chebyshev's and Khinchine's WLLN, Strong law of large numbers and Kolmogorov's theorem. |
| | | CLO - 5 | After completing this course, students should have developed a clear understanding of Central limit theorem, Lindeberg-Levy, Liapunov and Lindeberg-Feller forms of CLT. |
| 8 | Statistical Computing using C and Python ST - CE -8414 | CLO - 1 | After completing this course, students should have developed a clear understanding of basic of python programming and its application in analysing statistical data. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of visualisation of data and calculating various measures of central tendency as well as dispersion using Python. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of application of various parametric and nonparametric tests and fitting of various probability distributions using python. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concept of fitting of polynomials and exponential curves, Linear Regression for two variable, Multiple Regression analysis and Logistic Regression using python. |

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| 8 | Linear Algebra<br>ST - CE -8424 | CLO - 1 | After completing this course, students should have developed a clear understanding of concepts of linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space, linear space with inner product, orthogonalization of vectors and orthonormal basis of a linear space. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of concepts algebra of matrices, partitioned matrices. Canonical forms, generalized inverse, Moore – Penrose inverse. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concepts of Quadratic forms, Reduction of quadratic forms, Lagrange's method of transformation of a positive definite quadratic form and Cochran's theorem. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of concepts of Characteristic roots and vectors. |
| | Econometrics<br>ST-CE-8434 | CLO - 1 | After completing this course, students should have developed a clear understanding of Simple linear regression model. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of multiple linear regression model in matrix notation. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of violations of various assumptions under regression analysis viz. multicollinearity, heteroscedasticity, and autocorrelation. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of models of simultaneous relationships between various economic factors. |
| | Survival Analysis and Bio-Statistics<br>ST-CE-8444 | CLO - 1 | After completing this course, students should have developed a clear understanding of estimate and interpret death probabilities using competing risk models. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of apply survival analysis techniques and fit Cox proportional hazards models. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of design and analyse epidemiological studies and compute key association measures. |

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| 8 | | CLO - 4 | After completing this course, students should have developed a clear understanding of plan and evaluate clinical trials using suitable statistical tools. |
| | | CLO - 5 | After completing this course, students should have developed a clear understanding of explain basic genetic terminology and apply concepts to biological data. |
| | Distribution theory and Simulation ST - CE - 8454 | CLO - 1 | After completing this course, students should have developed a clear understanding of the basic tools of distribution theory, function of random variables and their distributions using Jacobian of transformation and other tools. |
| | | CLO - 2 | After completing this course, students should have developed a clear understanding of some basic distributions like Logarithmic, positive and negative multinomial distributions, probability distributions of extremes and its asymptotic distribution. |
| | | CLO - 3 | After completing this course, students should have developed a clear understanding of concept of censoring, truncation and weighted distributions; Mixture distributions and zero modified distributions. |
| | | CLO - 4 | After completing this course, students should have developed a clear understanding of non-central sampling distributions like non-central Chi-square and F distributions and results on other related distributions and proving their properties. |
| | | CLO - 5 | After completing this course, students should have developed a clear understanding of generating random variables from some basic distributions using Congruence method, inverse transform method and acceptance rejection method generation of random variables. |

## MAPPING OF PROGRAMME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO)

**Attributes:** Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

| Course Code | CLO | PROGRAMME OUTCOME | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO1 | SPO2 | SPO3 | SPO4 | SPO5 | SPO6 | SPO7 | SPO8 | SPO9 | SPO10 | SPO11 |
| ST-CE-1114 | CLO-1 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |
| | CLO-2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CLO-3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CLO - | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 |
| ST-CE-2114 | CLO-1 | 3 | 2 | 2 | | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 |
| | CLO-3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 |
| | CLO-4 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| ST-CE-3214 | CLO-1 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CLO-2 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| | CLO-3 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-3224 | CLO-1 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | | 2 |
| | CLO-2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | | 2 |
| ST-CE-4214 | CLO-1 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | CLO-2 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | CLO-3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| | CLO-4 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 |
| ST-CE-4224 | CLO-1 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-4234 | CLO-1 | 3 | | | | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| | CLO-2 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| | CLO-3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| ST-CE-5314 | CLO-1 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-5324 | CLO-1 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-5334 | CLO-1 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO-3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO-4 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | | 2 | 2 |

| Paper Code | CLO | PROGRAMME OUTCOME | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO1 | SPO2 | SPO3 | SPO4 | SPO5 | SPO6 | SPO7 | SPO8 | SPO9 | SPO10 | SPO11 |
| ST-CE-5344 | CLO-1 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 3 | 2 |
| | CLO-2 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 3 | 2 |
| | CLO-3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 3 | 2 |
| | CLO-4 | 3 | | | | | 2 | 1 | 1 | 1 | | 2 |
| ST-CE-6314 | CLO-1 | 3 | 1 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-6324 | CLO-1 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-6334 | CLO-1 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | CLO-2 | 3 | 2 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-3 | 3 | 2 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-4 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-6344 | CLO-1 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO-2 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 2 |
| | CLO-3 | 3 | 3 | 3 | 2 | 1 | 3 | 1 | 1 | 1 | 3 | 2 |
| | CLO-4 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-7414 | CLO1 | 3 | 1 | 2 | 1 | 1 | | 3 | 1 | 2 | 2 | 2 |
| | CLO2 | 2 | 2 | 1 | 1 | 2 | | 2 | 3 | 2 | 2 | 2 |
| | CLO3 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 |
| | CLO4 | 2 | 2 | 2 | 2 | 3 | 1 | 3 | 2 | 2 | 2 | 2 |
| | CLO5 | 1 | | | | 2 | 1 | 3 | 2 | 2 | 2 | 2 |
| ST-CE-7424 | CLO1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO2 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO4 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| ST-CE-7434 | CLO1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | CLO2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | CLO3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | CLO4 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 |
| ST-CE-7444 | CLO1 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 |
| | CLO2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 |
| | CLO3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO4 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| ST-CE-7454 | CLO1 | 2 | 3 | 2 | 2 | | | 1 | 2 | 2 | 2 | 2 |
| | CLO2 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| | CLO3 | 2 | 2 | 2 | | | 1 | 1 | 2 | 2 | 1 | 2 |
| | CLO4 | 2 | 2 | 2 | | | 1 | 1 | 2 | 2 | 1 | 2 |
| | CLO5 | 2 | 3 | 3 | | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| ST-CE-8414 | CLO1 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| | CLO2 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| | CLO3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 |
| | CLO4 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 3 | 2 | 3 |
| | CLO5 | 1 | 3 | 2 | 3 | 1 | 3 | 1 | 1 | 3 | 1 | 3 |

| Paper Code | CLO | PROGRAMME OUTCOME | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO1 | SPO2 | SPO3 | SPO4 | SPO5 | SPO6 | SPO7 | SPO8 | SPO9 | SPO10 | SPO11 |
| ST-CE-8424 | CLO1 | 3 | 2 | 2 | | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO2 | 3 | 2 | 2 | | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| | CLO4 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| ST-CE-8434 | CLO1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CLO2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CLO3 | 1 | 2 | 2 | | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CLO4 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| ST-CE-8444 | CLO1 | 3 | 2 | 2 | 2 | | 1 | 1 | 2 | 2 | 3 | 2 |
| | CLO2 | 3 | 2 | 2 | 2 | | 1 | 1 | 2 | 2 | 3 | 2 |
| | CLO3 | 3 | 2 | 2 | 2 | | 1 | 3 | 2 | 2 | 3 | 2 |
| | CLO4 | 3 | 2 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 3 | 2 |
| | CLO5 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 2 | 2 |
| ST-CE-8454 | CLO1 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CLO2 | 3 | 3 | 2 | 1 | | 1 | 2 | 2 | 2 | 2 | 2 |
| | CLO3 | 3 | 3 | 3 | 2 | | 1 | 2 | 3 | 3 | 2 | 2 |
| | CLO4 | 3 | 2 | 2 | 1 | | 1 | 2 | 2 | 2 | 2 | 2 |

## MAPPING OF PROGRAMME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOME (CLO)

**Attributes:** Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

| COURSE CODE | CLO | PROGRAMME SPECIFIC OUTCOME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
| ST-CE-1114 | CLO-1 | 3 | | | | 3 | 1 | 1 |
| | CLO-2 | 3 | 1 | 1 | 3 | 3 | 2 | 2 |
| | CLO-3 | 3 | 1 | 2 | 3 | 3 | 2 | 1 |
| | CLO-4 | 3 | 1 | 2 | 3 | 3 | 2 | 2 |
| | CLO -5 | 3 | 2 | 2 | 3 | 3 | 2 | 2 |
| ST-CE-2114 | CLO-1 | 3 | 2 | 3 | 3 | 3 | 2 | 2 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 2 | 3 | 3 | 2 | 2 | 1 |
| | CLO-4 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| ST-CE-3214 | CLO-1 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 |
| | CLO-4 | 3 | 1 | 2 | 3 | 2 | 1 | 1 |
| ST-CE-3224 | CLO-1 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | CLO-2 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| ST-CE-4214 | CLO-1 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | CLO-2 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 |
| | CLO-4 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| ST-CE-4224 | CLO-1 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 2 | 2 | 3 | 2 | 1 | 1 |
| | CLO-4 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| ST-CE-4234 | CLO-1 | 3 | | | | 2 | | 1 |
| | CLO-2 | 3 | 1 | 1 | 3 | 2 | 1 | 1 |
| | CLO-3 | 3 | 1 | 1 | 3 | 2 | 2 | 1 |
| | CLO-4 | 3 | 1 | 1 | 3 | 2 | 2 | 1 |
| ST-CE-5314 | CLO-1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| | CLO-4 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| ST-CE-5324 | CLO-1 | 3 | 2 | 1 | 3 | 1 | 1 | 1 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 2 | 1 |
| | CLO-3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| | CLO-4 | 3 | 3 | 2 | 3 | 3 | 2 | 1 |
| ST-CE-5334 | CLO-1 | 3 | 2 | 2 | 2 | 2 | 1 | 2 |
| | CLO-2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| | CLO-3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |
| | CLO-4 | 3 | 3 | 2 | 3 | 2 | 1 | 1 |

| COURSE CODE | CLO | PROGRAMME SPECIFIC OUTCOME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
| ST-CE-5344 | CLO-1 | 3 | 2 | 1 | 2 | 3 | 3 | 1 |
| | CLO-2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 |
| | CLO-3 | 3 | 2 | 2 | 3 | 3 | 1 | 2 |
| | CLO-4 | 3 | | | | 3 | | 2 |
| ST-CE-6314 | CLO-1 | 3 | 3 | | 3 | 2 | | 2 |
| | CLO-2 | 3 | 3 | 2 | 3 | 2 | 1 | 1 |
| | CLO-3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| | CLO-4 | 3 | 3 | 2 | 3 | 3 | 1 | 2 |
| ST-CE-6324 | CLO-1 | 3 | 2 | 2 | 3 | 2 | | 2 |
| | CLO-2 | 3 | 1 | 1 | 3 | 2 | 1 | 1 |
| | CLO-3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| | CLO-4 | 3 | 1 | 1 | 1 | 2 | 1 | 1 |
| ST-CE-6334 | CLO-1 | 3 | 1 | 1 | 2 | 3 | | 1 |
| | CLO-2 | 3 | 2 | 2 | 2 | 3 | 3 | 1 |
| | CLO-3 | 3 | 3 | 3 | 3 | 2 | 1 | 2 |
| | CLO-4 | 3 | 1 | 1 | 1 | 2 | 1 | 1 |
| ST-CE-6344 | CLO-1 | 3 | 2 | 2 | 3 | 2 | 2 | 2 |
| | CLO-2 | 3 | 1 | 2 | 1 | 2 | 2 | 1 |
| | CLO-3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 |
| | CLO-4 | 3 | 1 | 1 | 1 | 1 | | 1 |
| ST-CE-7414 | CLO1 | 3 | 2 | 1 | 1 | 1 | 2 | 1 |
| | CLO2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| | CLO4 | 2 | 2 | 3 | 2 | 2 | 2 | 1 |
| | CLO5 | | | | | 2 | 2 | 1 |
| ST-CE-7424 | CLO1 | 2 | | | 1 | 1 | 1 | 1 |
| | CLO2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| | CLO3 | 3 | 2 | 2 | 2 | | 1 | 1 |
| | CLO4 | 2 | 1 | 1 | 1 | | 1 | 1 |
| ST-CE-7434 | CLO1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | | 2 | 1 |
| | CLO4 | 3 | 2 | 2 | 2 | | 2 | 1 |
| ST-CE-7444 | CLO1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| | CLO4 | | 2 | 3 | 3 | 2 | 2 | 2 |
| ST-CE-7454 | CLO1 | 3 | 2 | 3 | 3 | | 2 | 1 |
| | CLO2 | 3 | 2 | 3 | 3 | | 2 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | | 2 | 1 |
| | CLO4 | | 2 | 2 | 2 | | 2 | 1 |
| | CLO5 | 2 | 3 | 3 | 3 | 1 | 2 | 1 |

| COURSE CODE | CLO | PROGRAMME SPECIFIC OUTCOME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PSO 1 | PSO 2 | PSO 3 | PSO 4 | PSO 5 | PSO 6 | PSO 7 |
| ST-CE-8414 | CLO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CLO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CLO3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | CLO4 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| | CLO5 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| ST-CE-8424 | CLO1 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| | CLO2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| | CLO4 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| ST-CE-8434 | CLO1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO4 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| ST-CE-8444 | CLO1 | 3 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO3 | 3 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO4 | 3 | 2 | 2 | 2 | 1 | 2 | 1 |
| | CLO5 | 2 | 2 | 2 | 2 | 1 | 2 | 1 |
| ST-CE-8454 | CLO1 | 3 | 2 | 3 | 3 | 1 | 2 | 1 |
| | CLO2 | 3 | 2 | 3 | 3 | 1 | 2 | 1 |
| | CLO3 | 3 | 3 | 3 | 3 | 1 | 3 | 1 |
| | CLO4 | 3 | 2 | 2 | 2 | 1 | 2 | 1 |

**COURSE NAME: Statistical Methods**

**COURSE CODE: ST – CE – 1114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVE:**

*The course objectives are as follows:*

- *To summarize the mass of data, to extract salient features from it and interpretation of results.*
- *To understand the concept of interpolation and numerical integration.*
- *To understand the concept of relationship between two variables.*

**Course Learning Outcome:**

*On completion of this course, students are expected to have a clear understanding of:*

**CLO-01:** *Concepts of statistical population and sample, variables and different scales of measurements.*

**CLO - 02:** *Diagrammatic and graphical presentation of data.*

**CLO - 03:** *Measures of central tendency, Dispersion, Moments, Skewness and Kurtosis.*

**CLO - 04:** *Interpolation techniques and Numerical Integration*

**CLO - 05:** *Correlation and Regression.*

**Unit 1: Statistical Data (Lectures: 10)**

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: Univariate Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic. Indian Knowledge System (IKS): Idea of IKS, Use of Statistics in Ancient India.

**Unit 2: Descriptive Statistics (Lectures: 15)**

Measures of Central Tendency: AM, GM, HM, Median and Mode. Partition Values: Quartiles, Deciles and Percentiles. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

**Unit 3: Calculus of Finite Difference (Lectures: 10)**

Finite Difference: Definition, Operators $\Delta$ & E, their properties, Difference table, missing terms, Interpolation: Definition, Newton's Forward and Backward interpolation formula, Lagrange's interpolation formula. Numerical Integration: Introduction, General quadrature formula, Trapezoidal, Simpson's 1/3rd & 3/8th rules.

**Unit 4**: **Bivariate Data (Lectures: 10)**

Bivariate data: Definition, scatter diagram, simple correlation, principle of least squares, Simple linear regression

## PRACTICAL

**Total Lectures: 30**

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Correlation coefficient for a bivariate frequency distribution
9. Lines of regression, angle between lines and estimated values of variables.
10. Problems based on Newton's Forward and Backward interpolation formula.
11. Problems based on Newton's Divided and Lagrange's interpolation formula.
12. Problems based on Trapezoidal, Simpson's $1/3^{rd}$ and Simpson's $3/8^{th}$ rules.

## BOOKS RECOMMENDED:


1. Barman M.P., Hazarika J. and Bora T. (2021), Statistical Methods, Mahaveer Publication
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, $8^{th}$Edn. The World Press, Kolkata.
3. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics,$11^{th}$ Edition. Sultan Chand and Sons, New Delhi.
4. Gupta P.P, Malik G.S. and Gupta S., (2006), Calculus of Finite Differences and Numerical Analysis, $34^{th}$Edn, Krishna Prakashan Media (P) Ltd, Meerut.
5. Kapur J.N. and Saxena H.C. (2001), Mathematical Statistics, S. Chand & Company LTD.
6. Medhi J. (2006), Statistical Methods,$2^{nd}$ Edition, New Age International (P) Limited
7. Yule, G.U. (1911). An Introduction to the Theory of Statistics. Journal of the Royal Statistical Society, 101(1), 225.

**COURSE NAME: Basic Probability Theory**

**COURSE CODE: ST – CE – 2114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 Credits**

**TOTAL LECTURES: 45**

**COURSE OBJECTIVE:**

*To familiarize the students with the:*

- *Concept of Probability theory, different laws and events and related theorems.*
- *Concept of random variables, Mathematical expectation, p.m.f, p.d.f. and generating functions.*
- *Idea of convergence in probability.*
- *Different standard probability distributions for both discrete and continuous random variables*

**Course Learning Outcome:**

*On completion of this course, students are expected to have a clear understanding of:*

**CLO – 01:** *Basic probability theory, random experiment, algebra of events, theorems and laws of probability*

**CLO – 02:** *Random variables, their expectations, moments, generating functions and probability functions.*

**CLO – 03:** *Probability inequalities, Laws of convergence and applications of law of large numbers.*

**CLO – 04:** *Important Discrete and continuous probability distributions.*

**Unit 1: Probability (Lectures: 15)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability and Bayes' theorem.

**Unit 2: Random Variables and Mathematical Expectation (Lectures: 10)**

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. Illustrations of random variables and its properties. Mathematical Expectation, variance and moment generating function.

**Unit 3: Convergence in Probability (Lectures: 10)**

Idea of convergence in probability, Modes of convergence, Chebyshev's inequality, Weak law of large numbers, Bernoulli's law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.) (statement only without proof).

**Unit 4: Standard Probability Distributions (Lectures: 10)**

Standard probability distributions: Bernoulli, Binomial, Poisson, Idea of Normal Distribution.

**PRACTICAL**

**Total Lectures: 30**

1. Application problems based on binomial distribution
2. Fitting of binomial distributions for n and p = q = 1⁄2 given
3. Fitting of binomial distributions for n and p given
4. Fitting of binomial distributions computing mean and variance
5. Application problems based on Poisson distribution
6. Fitting of Poisson distributions for given value of lambda
7. Fitting of Poisson distributions after computing mean
8. Application problems based on Normal distribution

**BOOKS RECOMMENDED:**


1. Choudhury, L, Sarma, R, Deka, M, Gogoi, S.J (2023): *Introduction to Statistics*
2. Feller, W.(1968b). *An Introduction to Probability Theory and Its Applications: Volume I*. John Wiley & Sons.
3. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8$^{th}$Edn. The World Press, Kolkata
4. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics, 11$^{th}$Edn. Sultan Chand and Sons, New Delhi.
5. Gupta O.P., Chaudhary S.S. Applied Statistics: Kedar Nath Ram Nath
6. Mood, A. M., & Graybill, F.A. (1911). An Introduction to the Theory of Statistics. Nature, 87(2185), 345.
7. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics.2$^{nd}$Edn. (Reprint) John Wiley and Sons.

**COURSE NAME: Statistical Methods II**

**COURSE CODE: ST - CE - 3214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

**Course Objectives:**

- *Concepts of Fitting of linear, nonlinear curve and orthogonal polynomial*
- *Concept of Bi-variate and Multivariate data*
- *Concept of Linear models*
- *Concept of theory of attributes*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Fitting of linear and nonlinear curve and orthogonal polynomial using data related to real world*

**CLO – 02**: *Bi-variate and Multivariate data and significance of various coefficients of correlation*

**CLO – 03**: *Concept of linear model, Simple regression model, Estimation of parameters and Hypothesis testing in case of simple regression models.*

**CLO – 04:** *Consistency, association and independence of attributes*

**Unit 1: Method of least squares and orthogonal polynomials (10 lectures)**

Principle of least squares, exponential curves and power curves, orthogonal polynomial, Fitting of all polynomials.

**Unit 2: Bi-variate and Multivariate data (15 lectures)**

Rank correlation, correlation ratio, intra class correlation, idea of multivariate data, multiple correlation and partial correlation (3 variables only), Idea of multiple regression

**Unit 3: Linear Models (10 lectures)**

Concept of linear model, Simple regression model, Estimation of parameters and Hypothesis testing in case of simple regression models.

**Unit 4: Theory of attributes (10 lectures)**

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency, Yule's Coefficient of association, Coefficient of Colligation.

**PRACTICAL**

**Total Lectures: 30**

1. Fitting of polynomials, exponential curves and power curve
2. Fitting of orthogonal polynomial
3. Spearman rank correlation with and without ties.
4. Partial and multiple Correlations.
5. Planes of regression and variances of residuals for given simple correlations.
6. Planes of regression and variances of residuals for raw data.
7. Simple linear regression
8. Estimation and hypothesis testing in case of simple regression models.
9. Consistency of attribute data
10. Independence and association of attributes

**BOOKS RECOMMENDED:**


1. Barman M.P., Hazarika J. and Bora T. (2021), Statistical Methods, Mahaveer Publication
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8thEdn. The World Press, Kolkata.
3. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics, 11th Edition. Sultan Chand and Sons, New Delhi.
4. Kapur J.N. and Saxena H.C. (2001), Mathematical Statistics, S. Chand & Company LTD.
5. Medhi J. (2006), Statistical Methods,2nd Edition, New Age International (P) Limited
6. Yule, G. U. (1911). An Introduction to the Theory of Statistics. Journal of the Royal Statistical Society, 101(1), 225.
7. Weisberg S. (2005). Applied Linear Regression ,3rd edition. Wiley

**COURSE NAME: Calculus**

**COURSE CODE: ST- CE - 3224**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

## Total Lectures: 45

**Course Objective**

*To familiarize the students with*

- *the concepts of Differential calculus and Integral calculus*
- *the concepts of Differential equations and partial Differential equations which in turn will help them to utilize this knowledge while solving various problems of Statistics.*

**Course Learning Outcome**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Concept of Differential calculus, Integral calculus and their applications*

**CLO – 02:** *Concept of Differential equations, Partial Differential Equations and their applications.*

**Unit 1: Differential Calculus (13 lectures)**

Limits of function, continuous functions, properties of continuous functions, partial differentiation and total differentiation. Indeterminate forms: L- Hospital's rule, Leibnitz rule for successive differentiation. Euler's theorem on homogeneous functions. Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) along with some problems. Jacobian.

**Unit 2: Integral Calculus (13 lectures)**

Review of integration and definite integral. Differentiation under integral sign, double integral, changes of order of integration, transformation of variables. Beta and Gamma functions: properties and relationship between them.

**Unit 3: Differential equations (15 lectures)**

Exact differential equations, integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Differential equations of first order but not of first degree, Equations solvable for x, y, q, Equations of the first degree in x and y, Clairaut's equations. Higher Order Differential Equations: Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals.

**Unit 4: Partial Differential Equations (4 lectures)**

Formation and solution of a partial differential equation. Equations easily integrable. Linear partial differential equations of first order.

**Tutorial:**

**Credit 1 (Lectures 15)**

**BOOKS RECOMMENDED:**


1. Boyce W., Di Prima R. C. (2009): Elementary Differential Equations and Boundary Value Problems, Wiley.
2. Hass Joel, Heil Christopher, Weir Maurice D. (2018): Thomas' Calculus, Pearson, 14th Edition.
3. Larson, R., & Edwards, B. (2013). Calculus (10th ed.). Brooks/Cole, Cengage Learning.
4. Malik S.C. and Arora Savita (1994): Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi.
5. Marsden Jerrold E., Tromba A. J., Weinstein A. (2005): Basic Multivariable Calculus, Springer.
6. Ross, S. L. (1984). Elementary Differential Equations (2nd ed.). Wiley.
7. Stewart, J. (2015). Essential Calculus: Early Transcendentals (2nd ed.). Cengage Learning.
8. Tan, S. T. (2013). Calculus: Early Transcendentals (1st ed.). Brooks/Cole, Cengage Learning

**COURSE NAME: Algebra**

**COURSE CODE: ST - CE - 4214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

**Course Objective:**

*To familiarize the students with*

- *The concepts of theory of equation*
- *The concepts of matrix algebra*
- *The concepts of Determinants of Matrices*
- *The concepts of rank of matrices, Characteristic roots, Characteristic vector and Quadratic forms which in turn will help them to utilize this knowledge while solving various problems of Statistics.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Concept of Theory of Equations and vector space*

**CLO – 02:** *Concept of different types of Matrices and inverse of matrix*

**CLO – 03:** *Concept of Determinants of Matrices and solution to the system of linear equations*

**CLO – 04:** *Concept of Rank of matrices, Characteristic roots, Characteristic vector and Quadratic forms of matrices.*

**Unit 1: Theory of Equations (10 lectures)**

Statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic equations.

**Unit 2: Algebra of Matrices (10 lectures)**

Idea of Matrices, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non- singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.

**Unit 3: Determinants of Matrices (13 lectures)**

Definition, properties and applications of determinants for $3^{rd}$ and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for $n^{th}$ order, Jacobi's Theorem, product of determinants. Use of determinants in solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX = B, solution sets of linear equations, linear independence, Applications of linear equations.

**Unit 4: Rank of Matrices (12 lectures)**

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of Characteristic roots, Cayley Hamilton Theorem.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals**

1. Adjoint and inverse of a matrix
2. Matrix equations AX = B and solution sets of linear equations
3. Rank of a matrix
4. Partitioning of matrices
5. Characteristic roots and Characteristic vector
6. Cayley Hamilton theorem
7. Quadratic forms

**BOOKS RECOMMENDED**


1. Artin, M.: Algebra. Prentice Hall of India, 1994.
2. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
3. Datta, K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
4. Gupta, S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
5. Hadley, G.: Linear Algebra, Narosa Publishing House (Reprint),2002.
6. Jain, P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
7. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
8. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition, 2006.
9. Searle, S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982
10. Vasishtha, A.R. (1982). Matrices (9th ed.). Krishna Prakashan Mandir

**COURSE NAME: Theory of Probability distributions**

**COURSE CODE: ST - CE - 4224**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

Course Objective:

*To familiarize the students with*

- *Concepts of two-dimensional random variable.*
- *Concept of generating function.*
- *Details of discrete Probability distribution.*
- *Details of continuous Probability distribution.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concept of two-dimensional random variables along with their joint, marginal and conditional p.m.f, p.d.f., and c.d.f.*

**CLO – 02**: *Concepts of cumulant generating function, characteristic function and Probability generating function.*

**CLO – 03**: *Concept of some important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hypergeometric and their interrelations.*

**CLO – 04**: *Concept of some important continuous distributions such as Uniform, Normal, Exponential, Lognormal, Laplace, Weibull, Gamma, Beta and Cauchy distributions.*

**Unit 1: Two dimensional random variables (8 lectures)**

Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, transformations of two-dimensional random variable with illustrations.

**Unit 2: Generating Functions (7 lectures)**

Moments and Cumulants, cumulant generating function, characteristic function. Probability generating function, Conditional expectations**.**

**Unit 3: Discrete Probability distribution (10 lectures)**

Geometric, Negative Binomial, Hyper-geometric, Multinomial distributions along with their characteristic properties and limiting/approximation cases.

**Unit 4: Continuous Probability distribution (20 lectures)**

Uniform, Normal, Exponential, Beta, Gamma, Cauchy, Log-normal, Laplace, Weibull, along with their properties and limiting/approximation cases.

**PRACTICAL**

**Total Lectures: 30**

**List of Practical**

1. Fitting of suitable distribution.
2. Application problems based on binomial distribution.
3. Application problems based on Poisson distribution.
4. Fitting of negative binomial distribution
5. Application problems based on negative binomial distribution.
6. Problems based on area property of normal distribution.
7. To find the ordinate for a given area for normal distribution.
8. Application based problems using normal distribution
9. Fitting of normal distribution when parameters are given.
10. Fitting of normal distribution when parameters are not given.
11. Fitting of Exponential distribution

**BOOKS RECOMMENDED:**


1. Choudhury L, Sarma R, Deka M, Gogoi S.J (2023) : An Introduction to Statistics
2. Feller, W (1993): An Introduction to Probability Theory and its Applications, Vol I, 9th Edition, Wiley Eastern Publication.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
4. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.16
5. Hunter, J. J. (1999). Mathematical techniques. Volume 1 & 2. John Wiley & Sons.
6. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
7. Mood, A.M., Graybill, F.A. and Bose, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint). Tata McGraw-Hill Pub. Co. Ltd.
8. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
9. Ross, S. M. (2020). Introduction to Probability models. 11th Edn. Academic Press.

**COURSE NAME: Applied Statistics I**

**COURSE CODE: ST - CE - 4234**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

**Course Objective:**

*To familiarize the students with*

- *Concepts of population theories.*
- *Concept of measurements of mortality and life table.*
- *Concept of measurements of fertility and population growth rates.*
- *Concept of Index number*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Knowledge of demographic data, Population composition and dependency ratio*

**CLO – 02:** *Concepts of measurement of population, Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. Concept of complete life table and abridge life table*

**CLO – 03:** *Concept of CBR, GFR), SFR, TFR, Crude rates of natural increase, Pearl's Vital Index, GRR) and NRR*

**CLO – 04:** *Index numbers and use of index numbers to real world problem.*

**Unit 1: Population Theory (5 lectures)**

Population Theories: Coverage and content errors in demographic data, use of balancing equations, Population composition, dependency ratio.

**Unit 2: Measurement of Mortality (17 lectures)**

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality Rate (IMR) and Standardized Death Rates. Stationary and Stable population, Central Mortality Rates and Force of Mortality. Life (Mortality)Tables: Assumption, description, Abridge Life table.

**Unit 3: Measurement of Fertility (13 lectures)**

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

**Unit 4: Index numbers (10 lectures)**

Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain-based index numbers and vice-versa. Consumer price index numbers.

**PRACTICAL**

**Total Lectures: 30**
**List of Practicals:**

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by: (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table.
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using

(i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method

6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them
9. Calculate Price and quantity index numbers using simple and weighted average of price relatives
10. Calculate the chain base index number.
11. Calculate consumer price index number.

**BOOKS RECOMMENDED:**


1. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9 th Edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New York.
6. Gupta S.C. and Kapoor V.K. (2002): Applied Statistics, 11th Edition. Sultan Chand and Sons, New Delhi.

## COURSE NAME: Mathematical Analysis

## COURSE CODE: ST - CE - 5314

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

Course Objective:

*To familiarize the students with*

- *The concepts of Real analysis*
- *The concepts of infinite series*
- *The concept of Limits, Continuity and Differentiability of functions*
- *The concepts of finite differences, interpolation and numerical integration which in turn will help them to utilize this knowledge while solving various problems of Statistics.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Concept of Real Analysis*

**CLO – 02:** *Concepts of infinite series*

**CLO – 03:** *Concept of Limits, Continuity and Differentiability of functions*

**CLO – 04:** *Concept of finite differences, interpolation and numerical integration*

**Unit 1: Real Analysis (8 lectures)**

Representation of real numbers as points on the line. Bounded and unbounded sets, neighbourhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as $r^n$,$(1 + 1/n)^n$ and $n^{\frac{1}{n}}$ and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

**Unit 2: Infinite Series (7 Lectures)**

Infinite series, positive termed series and their convergence; Comparison test, D'Alembert's ratio test, Cauchy's $n^{th}$ root test, Raabe's test (For all the tests, statement only is required, without proof and applications). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence.

**Unit 3: Limits, Continuity and Differentiability (15 lectures)**

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with Lagrange's and Cauchy's form of

remainder (without proof). Taylor's and Maclaurin's series expansions of sin (x), cos(x), $e^x$, $(1+x)^m$, log (1 + x).

**Unit 4: Numerical Analysis (15 lectures)**

Finite differences and interpolation. Operators $\Delta$,E and divided difference. Newton's forward and backward interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule and three-eight's rule, Weddle's rule.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

(Practical to be done from topics contained in Unit 4 only)

1. Newton's forward and backward interpolation formulae
2. Lagrange's interpolation formulae
3. Gauss and Stirling interpolation formulae
4. Numerical integration- Trapezoidal rule, Simpson's one-third rule and three-eight's rule and Weddle's rule.

**BOOKS RECOMMENDED:**


1. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, New Delhi,1987.
2. Atkinson K.E. (2008): An Introduction to Numerical Analysis, 2nd Edition, Wiley India Private Limited, New Delhi.
3. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore.
4. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
5. Gupta, S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi,1995.
6. Jain M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
7. Malik, S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
8. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
9. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rdedition, Prentice Hall of India Pvt. Ltd., New

10. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
11. Singal, M.K. and Singal, A.R.: A First Course in Real Analysis, 24th Edition, R. Chand & Co., New Delhi, 2003.
12. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.

## COURSE NAME: Sampling Distributions

## COURSE CODE: ST - CE - 5324

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

**Course Objective**:

*To familiarize the students with*

- *Concepts of order statistics*
- *Concept of Sampling Distributions for large samples, Z test and its applications*
- *Concept of chi square distribution and its application.*
- *Concept of t and F distribution along with their applications.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Distribution of ordered statistics and their applications.*

**CLO – 02**: *Concepts of sampling distribution of statistic and large sample test i.e. Z test for proportion, mean and standard deviation for single sample as well as two sample cases*

**CLO – 03**: *Concept of chi square distribution, its properties and applications.*

**CLO – 04:** *Concept of t, F distributions, their properties and applications.*

**Unit 1: Order Statistics (5 lectures)**

Introduction, distribution of the $r^{th}$ order statistic, smallest and largest order statistics. Joint distribution of $r^{th}$ and $s^{th}$ order statistics, distribution of sample median and sample range.

**Unit 2: Sampling Distributions for large samples (10 lectures)**

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion. Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Large sample tests, testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches.

**Unit 3: Chi square Distributions (15 lectures)**

Definition and derivation of p.d.f. of $\chi^2$ with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode,

additive property and limiting form of $\chi 2$ distribution. Tests of significance and confidence intervals based on distribution.

**Unit 4: Sampling Distribution (t and F distributions) (15 lectures)**

Student's and Fishers t-distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of 1/F (n1, n2). Relationship between t, F and $\chi 2$ distributions.

**PRACTICAL**

**Total Lectures: 30**
**List of Practicals:**

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.5. Testing if the population variance has a specific value and its confidence intervals.
5. Testing of goodness of fit.
6. Testing of independence of attributes.
7. Testing based on 2 X 2 contingency table without and with Yates' corrections.
8. Testing of significance and confidence intervals of an observed sample correlation coefficient.
9. Testing and confidence intervals of equality of two population variances

**BOOKS RECOMMENDED:**


1. Das Kishore K., Bhattacharjee D. (2008), A treatise on Statistical Inference and distribution, Asian book Private limited
2. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): An Outline of Statistical Theory, Vol. I, 4$^{th}$Edn. World Press, Kolkata.
3. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.16
4. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
5. Johnson, R.A. and Bhattacharya, G.K. (2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
6. Kapur J.N. and Saxena H.C. (2001), Mathematical Statistics, S. Chand & Company LTD.

7. Medhi J. (2006), Statistical Methods, 2nd Edition, New Age International (P) Limited
8. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rdEdn. (Reprint). Tata McGraw-Hill Pub. Co. Ltd.
9. Mukhopadhyay, P. (1999): Mathematical Statistics, Books and Allied (P) Ltd.
10. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics.2ndEdn. (Reprint) John Wiley and Sons.

## COURSE NAME: Statistical Inference I

## COURSE CODE: ST - CE - 5334

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

Course Objective:

*To familiarize the students with*

- *Concepts of Estimation and its characteristics*
- *Concept of Minimum variance unbiased estimators*
- *Concept of methods of estimation*
- *Concept of interval estimation.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of Estimation and its characteristics namely unbiasedness, sufficiency, consistency and efficiency,*

**CLO – 02**: *Concepts of Minimum variance unbiased estimators and MVB estimators*

**CLO – 03**: *Concept of methods of estimation namely Method of moments, method of maximum likelihood estimation and method of minimum Chi- square*

**CLO – 04:** *Concept of interval estimation.*

**Unit 1: Characteristics of Estimation (15 lectures)**

Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem, Complete statistic.

**Unit 2: MVUE (10 lectures)**

Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems (statement only). Cramer-Rao inequality and MVB estimators.

**Unit 3: Methods of Estimation (12 lectures)**

Method of moments, method of least square estimation, method of minimum Chi- square, method of maximum likelihood estimation, method of scoring

**Unit 4: Interval Estimation (8 lectures)**

Confidence intervals, one sided confidence interval, confidence interval for difference in means, confidence interval for ratio of variances, shortest length confidence interval

**PRACTICAL**

**Total Lectures: 30**

**List of Experiments**

1. Unbiased estimators (including unbiased but absurd estimators)
2. Consistent estimators, efficient estimators and relative efficiency of estimators.
3. Sufficient Estimators –Factorization Theorem, Complete Sufficient estimators
4. UMVUE
5. Maximum Likelihood Estimation
6. Estimation by the method of moments
7. Confidence interval Estimation

**BOOKS RECOMMENDED:**


1. Bhat, B.R, Srivenkatramana, Tand Rao Madhava, K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
2. Das Kishore K., Bhattacharjee D. (2008), A treatise on Statistical Inference and distribution, Asian book Private limited
3. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
4. Goon, A.M., Gupta, M.K.: Das Gupta, B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
5. Gupta S.C and Kapoor V.K (2007): Fundamentals of Mathematical Statistics, 11th Edition, Sultan Chand & Sons.16
6. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
7. Mood, A.M, Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, McGraw Hill.
8. Mukhopadhyay, P. (2000): Mathematical Statistics, Books and Allied (P) Ltd.
9. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics.2ndEdn. (Reprint) John Wiley and Sons.
10. Snedecor, G.W and Cochran, W.G. (1967) Statistical Methods. Iowa State University Press.

## COURSE NAME: Survey Sampling and Indian Official Statistics

## COURSE CODE: ST - CE - 5344

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

Course Objective:

*To familiarize the students with*

- *Concepts of simple random sampling with and without replacement*
- *Concept of stratified random sampling, Systematic Sampling, PPS sampling and two stage sampling*
- *Concept of Ratio and Regression Method of Sampling, Cluster sampling and sub sampling*
- *Knowledge of Indian official Statistics.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of non-probability and probability sampling, simple random sampling with and without replacement, procedure of selecting a sample and estimation of population mean, total and proportion in SRS*

**CLO – 02**: *Concepts of stratified random sampling and Systematic Sampling along with estimation of population mean and total in these methods, Brief idea about PPS sampling and two stage sampling*

**CLO – 03**: *Concept of Ratio and Regression Method of Sampling, Cluster sampling and sub sampling*

**CLO – 04:** *Knowledge about Indian official Statistics*

**Unit 1: Survey Sampling (12 lectures)**

Concept of population and sample, complete enumeration versus sampling, sampling and non- sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, procedure of selecting a sample, estimates of: population mean, total and proportion.

**Unit 2: Stratified Random Sampling and other sampling techniques (16 lectures)**

Stratification technique, estimation of population means, variance of the estimate, proportional and optimum allocations and their comparison with SRS. Estimation of gain in precision. Systematic Sampling: Technique, estimates of population mean, variance of the estimates (N=nk). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend. Introduction to PPS sampling and two stage sampling.

**Unit 3: Ratio and Regression Method of Sampling (10 lectures)**

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), Idea of Cluster sampling and multistage sampling.

**Unit 4: Official Statistics (7 lectures)**

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

**PRACTICAL**

**Total Lectures: 30**

**List of Practical**

1. To select SRS with and without replacement.

2. For a population of size 5, estimate population mean, population mean square andpopulation variance. Enumerate all possible samples of size 2 by WR and WOR and establishall properties relative to SRS.

3. For SRSWOR, estimate mean, standard error, the sample size

4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS

5. Estimation of gain in precision in stratified sampling.

6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.

7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.

**BOOKS RECOMMENDED:**


1. Cochran, W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy, M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok, P. (1998): Sample Survey Theory, Narosa Publishing House.

5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Gupta S.C. and Kapoor V.K. (2002): Applied Statistics, 11th Edition. Sultan Chand and Sons, New Delhi.
7. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.
8. http://mospi.nic.in

## COURSE NAME: Operations Research

## COURSE CODE: ST - CE - 6314

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

**Course Objective:**

*To familiarize the students with*

- *Concepts of operation research and Linear Programming Problem*
- *Concept of Transportation Problem*
- *Concept of Game Theory*
- *Concept of Inventory Control*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Various types of Operations Research problems, Mathematical formulation of LPP, graphical solutions of a L.P.P and Simplex method for solving L.P.P.*

**CLO – 02**: *Transportation Problems and initial solution by North West corner rule, least cost method and Vogel's approximation method (VAM).*

**CLO – 03**: *Game theory, rectangular game and minimax-maximax principle*

**CLO – 04***: Inventory Management, ABC inventory system, EOQ Model and Quantity Discount Model with price breaks.*

**Unit 1: Introduction to OR and LPP (8 lectures)**

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P.

**Unit 2: Transportation Problem (13 lectures)**

Transportation Problem: Initial solution by North West corner rule, least cost method and Vogel's approximation method (VAM).

**Unit 3: Game Theory (12 lectures)**

Game theory: Rectangular game, minimax-maximax principle, Dominance property

**Unit 4: Inventory Control (12 lectures)**

Inventory Management: Characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks, ABC inventory system.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation
   a. Degenerate solution
   b. Unbounded solution
   c. Alternate solution
   d. Infeasible solution
3. Allocation problem using Transportation model
4. Networking problem
   a. Minimal spanning tree problem
   b. Shortest route problem
5. Problems based on game matrix
   a. Graphical solution to m× 2 / 2×n rectangular game
   b. Mixed strategy
6. To find optimal inventory policy for EOQ models and its variations
7. To solve all-units quantity discounts model

**BOOKS RECOMMENDED:**


1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002): Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases,9th Edition, Tata Mc Graw Hill
5. Gupta R.K. (2014), Operations Research, 33rd edition, Krishna Prakashan Media (P) LTD.
6. Sharma S.D. (2005), Operations Research,15th edition, Kedar Nath Ram Nath &Co.

## COURSE NAME: Analysis of Variance and Design of Experiment

## COURSE CODE: ST - CE - 6324

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

**Course Objective:**

*To familiarize the students with*

- *Concepts of analysis of variance in one-way and two way classified data*
- *Concept of Basic designs namely Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD*
- *Concept of Factorial Experiments*
- *Concept of Split plot, strip plot design, and BIBD*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01:** *Concepts of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data as well as two-way classified data for fixed effect models.*

**CLO – 02:** *Concepts of Basic designs namely Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) along with their layouts, models and statistical analyses*

**CLO – 03:** *Concepts of analysis of $2^2$, $2^3$…and $2^n$ factorial experiments along with total and partial confounding.*

**CLO – 04:** *Ideas of Split plot, strip plot design and BIBD*

**Unit 1: Linear models and Analysis of variance (10 lectures)**

Linear model, fixed, random and mixed effect models, analysis of variance in one-way classified data for fixed effect models, analysis of variance in two-way classified data for fixed effect models.

**Unit 2: Basic Designs (12 lectures)**

Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, choice of size and shape of plots and blocks. Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations in RBD and LSD, Graeco Latin Square Design.

**Unit 3: Factorial Experiments (13 lectures)**

Factorial experiments: advantages, notations and concepts, $2^2$, $2^3 \ldots 2^n$ factorial experiments, design and analysis, Total and Partial confounding for $2^n$ ($n \leq 5$),

**Unit 4: Idea of Split plot and strip plot design and BIBD (10 lectures)**

Split Plot Design, Strip Plot Design, Incomplete Block Designs, Introduction to Balanced Incomplete Block Design (BIBD)

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals**

1. Analysis of Variance of one way classified data
2. Analysis of Variance of two way classified data with one observation per cell
3. Analysis of an RBD
4. Analysis of an LSD
5. Analysis of an RBD with one missing observation
6. Analysis of an LSD with one missing observation
7. Analysis of $2^2$ and$2^3$ factorial in CRD and RBD
8. Analysis of a completely confounded two level factorial design in 2 blocks
9. Analysis of a completely confounded two level factorial design in 4 blocks
10. Analysis of a partially confounded two level factorial design.

**BOOKS RECOMMENDED:**


1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Gupta S.C. and Kapoor V.K. (2002): Applied Statistics, 11th Edition. Sultan Chand and Sons, New Delhi.
5. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
6. Montgomery, D. C. (2008): Design and Analysis of Experiments, John
7. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.

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## COURSE NAME: Statistical Inference II

## COURSE CODE: ST - CE - 6334

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

**Course Objective**:

*To familiarize the students with*

- *Concepts of principles of test of significance*
- *Concept of different tests of hypothesis*
- *Concept of Likelihood ratio test*
- *Concept of Sequential Analysis*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of simple and composite hypotheses, non-randomized test and randomized test and best critical region*

**CLO – 02:** *Concepts of Most powerful test, uniformly most powerful test, unbiased test and Neyman Pearson Lemma to construct most powerful test.*

**CLO – 03:** *Concepts and applications of Likelihood ratio test*

**CLO – 04:** *Ideas of Sequential probability ratio test (SPRT) and Wald's sequential probability ratio test.*

**Unit 1: Principles of Tests of Significance (10 lectures)**

Simple and composite hypothesis, non-randomised test and randomised test, critical region, level of significance, size and power, best critical region.

**Unit 2: Different Tests of Hypothesis (18 lectures)**

Most powerful test, uniformly most powerful test, Unbiased test, Neyman Pearson Lemma (statement and applications to construct most powerful test).

**Unit 3: Likelihood ratio test (12 lectures)**

Likelihood ratio test, properties of likelihood ratio tests (without proof), Application of LR test

**Unit 4: Sequential Analysis (5 lectures)**

Sequential Analysis: Introduction to Sequential probability ratio test (SPRT), Wald's sequential probability ratio test.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Type I and Type II errors
2. Most powerful critical region (NP Lemma)
3. Uniformly most powerful critical region
4. Unbiased critical region
5. Power curves
6. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
7. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis

**BOOKS RECOMMENDED:**


1. Bhat, B.R, Srivenkatramana, Tand Rao Madhava, K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
2. Das Kishore K., Bhattacharjee D. (2008), A treatise on Statistical Inference and distribution, Asian book Private limited
3. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
4. Goon, A.M., Gupta, M.K.: Das Gupta, B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
5. Miller, I. and Miller, M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
6. Mood, A.M, Graybill, F.A. and Boes, D.C.: Introduction to the Theory of Statistics, McGraw Hill.
7. Mukhopadhyay, P. (2000): Mathematical Statistics, Books and Allied (P) Ltd.
8. Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics.2ndEdn. (Reprint) John Wiley and Sons.
9. Snedecor, G.W and Cochran, W.G. (1967) Statistical Methods. Lowa State University Press.

## COURSE NAME: Multivariate Analysis and Non-Parametric Tests

## COURSE CODE: ST - CE - 6344

## Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

### THEORY

### Total Lectures: 45

**Course Objective:**

The learning objectives include:

- To study the theoretical concepts of Bivariate Normal and Multivariate Normal Distributions along with their properties.
- Application of non-parametric methods of testing of hypothesis.

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO - 01**: Understand and analyse the concepts of Bivariate Normal Distribution and its properties.

**CLO - 02**: Understand and evaluate multivariate data and related characteristics, the concepts and properties of Multivariate Normal Distributions and Multinomial Probability Distributions.

**CLO - 03**: Apply the theory of Hotelling$T^2$ in Multivariate inferential problems.

**CLO - 04**: Understand and apply the different non-parametric test procedures, their applications and interpretation.

**Unit 1: Bivariate normal distribution (10 lectures)**

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional p.d.f. of BVN.

**Unit 2: Multivariate distributions (8 lectures)**

Multivariate Data: Random Vector, probability mass/density functions, distribution function, mean vector & Dispersion matrix, Marginal and Conditional distributions, Multinomial distribution: mgf, pgf, mean, variance-covariance matrix.

**Unit 3: Multivariate normal distribution (12 lectures)**

P.d.f. of Multivariate normal and its properties, Characteristic functions, Marginal & Conditional distributions. Hotelling $T^2$- concept, and applications (one sample and two samples).

**Unit 4: Non-Parametric Tests (15 lectures)**

Introduction and Concept, Test for randomness based on runs (both one and two sample tests), Empirical distribution function, Kolmogorov Smirnov test for one and two samples, Sign tests- one sample and two samples, Wilcoxon-Mann- Whitney test, Kruskal-Wallis test, Wilcoxon signed rank test, Median test.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Bivariate Normal Distribution: estimation of parameters.
2. Multivariate Normal Distribution: estimation of parameters and related test of significance.
3. Hotelling $T^2$ and related tests based on single and double mean.
4. Test for randomness based on total number of runs,
5. Kolmogorov-Smirnov test for one sample.
6. Sign test: one sample, two samples, large samples.
7. Wilcoxon-Mann-Whitney U-test
8. Kruskal-Wallis test.

**BOOKS RECOMMENDED**


1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley
2. Gibbons, J.D. and Chakraborty, S (2003): Nonparametric Statistical Inference. 4th Edition. Marcel Dekker, CRC.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2005): An Outline of Statistical Theory, Volume II, World Press
4. Johnson, R. A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edition, Pearson & Prentice Hall
5. Kshirsagar, A.M. (1972): Multivariate Analysis, 1st Edn. Marcel Dekker.
6. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
7. Mukhopadhyay, P., Mathematical Statistics. New Central Book Agency
8. Rao, C.R. (2000): Linear Statistical Inference, Wiley.
9. McColl, John H (2004), Multivariate Probability, Int Edn, Hodder Education Publishers.
10. Mardia, K.V., J.T. Kent, J. M. Bibby (1979): Multivariate Analysis. Academic Press.

# COURSE NAME: Research Methodology
# COURSE CODE: ST – CE - 7414
# Total Credits: 4 (Theory: 3 + Project work: 1)

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES (COs):**

The course objectives are to familiarize students with -

- *The fundamental concepts, types, and process of research.*
- *Developing skills in sourcing, analysing, and interpreting qualitative and quantitative data.*
- *The use ICT tools and online resources for research activities.*
- *Building competence in academic writing, presentation, and scholarly communication.*
- *Creating awareness of ethical, legal, and professional regulations in research, including patents and copyrights.*

**Course Learning Outcomes (CLOs):**

After successful completion of the course, learners are expected to have a clear understanding of:

**CLO-01:** *The key research concepts and application of appropriate research methods.*

**CLO-02:** *Collection, analysis, and interpretation of data using suitable tools and techniques.*

**CLO-03:** *ICT platforms, online databases, and digital tools for effective research work.*

**CLO-04:** *Preparation of well-structured research reports and delivery of scientific presentations confidently*.

**CLO-05: *U****nderstanding of intellectual property rights, cyber laws, and ethical research practices.*

**Unit 1**: **Foundations of Research (Lecture: 10)**

Meaning, characteristics and types of research, Steps of the research process, Research communication: paper, article, workshop, seminar, conference, symposium, Thesis and dissertation writing: characteristics, structure, and format, Literature survey: accessing articles, library/online search strategies, Review of research papers and preparation of a short report.

**Unit 2**: **Data and Interpretation (Lecture: 10)**

Sources of data: primary and secondary, Acquisition, classification, and interpretation of data, Quantitative and qualitative data, Graphical and tabular presentation of data, charts, figures, and formats used in research.

**Unit 3: ICT in Research and Scientific Communication (Lecture: 15)**

ICT: meaning, applications, advantages, and limitations, Research-related abbreviations and terminology, Basics of internet use, online communication, and email etiquette, Use of internet resources for research: downloading papers, online submission, academic databases, journal platforms

**Unit 4**: **Scientific Writing, Presentation, and Legal Aspects (Lecture: 10)**

Art of scientific writing: structure, flow, and language, preparing figures, graphs, tables, footnotes, and references, Preparing and presenting seminar papers (PowerPoint/poster) Presentation skills: communication, audience engagement, Q&A strategies, Introduction to patent laws, copyright, and cyber laws in research.

**Project Work: (Credit: 1)**

**Objective:**

The aim of the project work is to encourage students to write and present a statistical report, under the supervision of a faculty, on some area of human interest. The project work will provide hands on training to the students to deal with data emanating from some real life situation and propel them to dwell on some theory or relate it to some theoretical concepts, taught in the course.

**Suggested Readings:**


1. Donald R. Cooper and Pamela S. Schindler (2020): Business Research Methods, McGraw Hill, 2020.
2. Kothari, C.R. (2009): Research Methodology: Methods and Techniques, 2nd Revised Edition reprint, New Age International Publishers.
3. Kumar, R (2011): Research Methodology: A Step-by-Step Guide for Beginners, SAGE publications.
4. Nicholas Walliman (2017): Research Methods: The Basics, Routledge.
5. R. Panneerselvam (2019): Research Methodology: A Step-by-Step Guide, PHI Learning.
6. Richard I. Levin and David S. Rubin (2017): Statistics for Management, Pearson.
7. S. S. Khanka (2018): Research Methods for Business and Management, Sultan Chand & Sons.

## COURSE NAME: Stochastic Process and Queuing Theory
## COURSE CODE: ST - CE - 7424
## Total Credits: 4 (Theory: 3 + Practical: 1)

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES:**

The course objectives are to familiarize the students with-

- *Concepts of Stochastic processes and Stationary Processes*
- *Concept of Markov chains and its applications*
- *Concept of Poisson process.*
- *Concept of Queuing theory and its applications.*

**Course Learning Outcomes**:

After completing this course, students should have developed a clear understanding of:

**CLO–01:** Concepts of Stochastic processes along with its specifications and Stationary Processes.

**CLO–02**: Concepts of Markov Chain, transition probability matrix, order of Markov chain, higher transition probabilities, classification of states and chains.

**CLO–03:** Concepts of Poisson Process along with its properties, inter-arrival time, generalization of Poisson Process and Birth- Death process

**CLO–04:** Concept of Queuing theory, M/M/1 queuing model with finite and infinite system capacity.

**Unit 1: Stochastic Process (Lectures 5)**

Concept and definition, Specification of Stochastic process, Stationary Processes.

**Unit 2: Markov Chains: (Lectures: 15)**

Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities, generalization of independent Bernoulli trials, classification of states and chains.

**Unit 3: Poisson Process: (Lectures: 15)**

Definition of Poisson process, Postulates of Poisson process, properties of Poisson process, inter-arrival time, Generalization of Poisson process, Birth- Death process.

**Unit 4: Queuing System: (Lectures: 10)**

General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution (without proof).

**PRACTICAL**

Total Lectures: 30

List of Practicals:

1. Calculation of transition probability matrix
2. Identification of characteristics of reducible and irreducible chains.
3. Identification of types of classes
4. Identification of ergodic transition probability matrix
5. Stationarity of Markov chain and graphical representation of Markov chain
6. Computation of probabilities in case of generalizations of independent Bernoulli trials.
7. Computation of inter-arrival time for a Poisson process.
8. Calculation of Probability and parameters for (M/M/1) model and change in behaviour of queue as N tends to infinity.
9. Calculation of generating function and expected duration for different amounts of stake.

**Recommended Books:**


1. Adke, S. R and Manjunath S. M (1984) An Introduction to Finite Markov Processes.
2. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.
3. Bhat, B.R. (2000): Stochastic Models: Analysis and Applications, New Age International Publishers.
4. Cinler, E (1975) Introduction to Stochastic Processes, Prentice Hall.
5. Feller, William (1968): Introduction to probability Theory and Its Applications, Vol I, 3rd Edition, Wiley International.
6. Hoel, P. G, Port, S.C, Stone, C.J (1972) Introduction to Stochastic Processes, Houghton Miffin and Co.
7. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
8. Taha, H. (1995): Operations Research: An Introduction, Prentice- Hall India.

# COURSE NAME: Applied Statistics II
# COURSE CODE: ST - CE - 7434
# Total Credits: 4 (Theory: 3 + Practical: 1)

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES**:

The course objectives are to familiarize the students with -

- Concepts of time series, its composition and decomposition
- Concept of forecasting of time series
- Concept of Statistical product control
- Concept of acceptance Sampling Plan

**Course Learning Outcome**:

After completing this course, students should have developed a clear understanding of:

**CLO – 01**: Concepts and application of time series from various fields, Components of times series, Decomposition of time series, estimation of trend and seasonal component.

**CLO – 02**: Concepts of exponential smoothing methods, Stationary and non-stationary time series, ARMA and ARIMA models

**CLO – 03**: Concepts of control charts for variables and attributes.

**CLO – 04**: Concepts of single and double sampling plan.

**Unit 1: Introduction to Time Series: (Lectures: 15)**

Introduction to times series data, application of time series, Components of times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, method of moving averages fitting a various mathematical curve, growth curves, De trending, effect of elimination of trend on other components of the time series, Seasonal Component: Estimation of seasonal component by method of simple averages, Ratio to Trend. Ratio to Moving Averages and Link Relative method, measurement of Cyclic variation, Harmonic analysis, Random Component: Variate component method.

**Unit 2: Forecasting (Lectures: 10)**

Exponential smoothing methods, Stationary processes, auto-covariance, auto-correlation, Partial auto-correlation function, Correlellogram, Autoregressive model, Moving Average model, Idea of ARMA model, non-stationary time series, Idea of ARIMA

**Unit 3: Statistical Process Control (Lectures: 10)**

Quality: Definition, dimensions of quality, Control Charts, Statistical basis of 3-σ Control limits, control charts for variables: X-bar & R-chart, X-bar & s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u chart, Overview of Six Sigma.

**Unit 4: Acceptance Sampling Plan: (Lectures: 10)**

Principle of acceptance sampling plans. Single and Double sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Forecasting by exponential smoothing
9. Construction and interpretation of statistical control charts: X-bar & R-chart, X-bar & s-chart, np-chart, p-chart, c-chart and u-chart.
10. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves

**Recommended Books:**


1. Anderson, T.W. (1971), Statistical Analysis of Time Series, Wiley, NY
2. Box, G.E.P and Jenkins, G.M. (1976). Time series Analysis-Forecasting and Control, Holden-day, San Fransisco.
3. Brokckwell, P.J. and Davis, R.A. (1996). Introduction to Time Series and Forecasting, Springer, New York.
4. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
5. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
6. Kendall M.G. (1976): Time Series, Charles Griffin.

7. Medhi, J. (2009). Stochastic Processes, 3rd Ed., New Age International Publishers, New Delhi, India.
8. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
9. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
10. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied

**COURSE NAME: Advanced Multivariate Analysis**

**COURSE CODE: ST-CE-7444**

**Total Credits: 4 (Theory: 3 + Practical: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES:**

The course objectives are to familiarize the students with –

- *The concept of Multivariate normal distributions along with their properties.*
- *Analysis of Multivariate data.*
- *Study of Wishart matrix and its properties*
- *Dimension reduction techniques*

**Course Learning Outcomes:**

On completion of the course, students should have achieved the following:

**CLO-01:** *The understanding of basic concepts associated with Multivariate normal distributions and their properties.*

**CLO-02:** *Techniques for analyzing multivariate data like MANOVA.*

**CLO-03:** *Analysing Multivariate data using data reduction techniques like Principal Component Analysis, Canonical Correlation Analysis, Idea of Factor Analysis.*

**CLO-04:** *Classification method namely Discriminant Analysis.*

**Unit 1: Multivariate normal distribution: (Lectures: 12)**

Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Multivariate Central Limit Theorem.

**Unit 2: Wishart Matrix: (Lectures: 12)**

Distribution of Wishart matrix and its properties. Distribution of sample generalized variance, Mahalanobis' $D^2$, Distribution of Hotelling's $T^2$ statistic (without derivation), Applications of Hotelling $T^2$ for testing mean vector for one and more multivariate normal populations.

**Unit 3: Multivariate Tests (Lectures:12)**

Likelihood ratio test, criteria for testing independence of sets of variables, equality of covariance matrices. Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, its distribution and applications, Multivariate analysis of

variance (MANOVA) of one-way classified data.

**Unit 4: Dimension Reduction Techniques (Lectures:12)**

Concept of dimension reduction, Principal component analysis, Canonical variables and Canonical correlation, use, estimation and computation; Idea of Factor Analysis.

**List of Practicals:**

1. Estimation of Parameters
2. Distribution of sample mean vector
3. Finding number of factors from a set of variables
4. Finding number of principle components from a set of variables
5. Hotelling's $T^2$ in tests on mean vector for one and more multivariate normal populations.
6. Multivariate analysis of variance (MANOVA) of one-way classified data.

**Recommended Books:**


1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edition, John Wiley.
2. Chakravarti, I. M, Lahe, R.G & Roy, A Hand Book of Methods of Applied Statistics, Vol-1, John Wiley.
3. Giri, N.C. (1977): Multivariate Statistical inference, Academic Press.
4. Hardle, W. K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, 4th Edition, Springer. Pearson Education India.
5. Johnson, R.A. and Wichern, D.W. (2015): Applied Multivariate Statistical Analysis, 6th Edition, Prentice Hall.
6. Kshirsagar, A.M. (1996): Multivariate Analysis, 2nd Edition, Marcel Dekker.
7. Lawley, D.N. and Maxwell, A.E. (1971): Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
8. Muirhead, R. J. (1982): Aspects of Multivariate Statistical Theory, Wiley.
9. Rao, C. R. (1972): Linear Statistical inference and its Application, John Wiley
10. Srivastava, M.S. and Khatri, C.G. (1979): An introduction to Multivariate Statistics, North-Holland.

**COURSE NAME: Measure Theory and Probability**

**COURSE CODE: ST-CE-7454**

**Total Credits: 4 (Theory: 3 + Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES**:

The objectives of offering the course are-

- *to learn basic concepts of Measure theory*
- *to learn Measurable functions and Lebesgue measure*
- *to learn the concepts of Moment inequalities*
- *to learn different concepts of laws of large numbers*

**Course Learning Outcomes**:

After completing this course, students should have developed a clear understanding of:

**CLO-01**: *Probability measure, properties of a measure, Lebesgue-Stieltjes measure.*

**CLO-02**: *Outer measure, class of outer measurable sets in a Sigma field.*

**CLO-03**: *Moment inequalities, Characteristic functions, continuity theorems, Modes of convergence and their interrelations*

**CLO-04**: *Chebyshev's and Khinchine's WLLN, Strong law of large numbers and Kolmogorov's theorem.*

**CLO-05**: *Central limit theorem, Lindeberg-Levy, Liapunov and Lindeberg-Feller forms of CLT.*

**Group-A (Measure Theory)**

**Unit 1: Basic concepts of Measure Theory (Lectures: 10)**

Measure-it's properties with examples, finite and Sigma finite Measure, Continuity theorem of Measure, Probability space and conditional probability space, Lebesgue-Stieltjes Measure, Idea of product space and product Measure, Outer Measures, outer measurability, class of outer measurable sets in a Sigma field.

**Unit 2: Measurable function and Lebesgue measure (Lectures: 13)**

Construction of outer measure function, Lebesgue measure, Lebesgue Measurable sets, extension of measure on a field, complete measure space. Measurable transformation and function, random variable, simple and Elementary function, induced measure and distribution function, properties

of measurable functions, measurable function as the limit of simple function

## Group-B (Probability)

**Unit 1: Moment Inequality (Lectures: 12)**

Moment inequalities: Markov's, Cramer's, Holder's and Jenson inequalities. Characteristic functions: uniqueness and inversion theorems. Convergence of sequence of random variables and modes of convergence (convergence in probability, almost surely, mean square and in distribution) and their interrelations.

**Unit 2: Laws of large Numbers (Lectures:10)**

Idea of Laws of large numbers, Chebyshev's, Khinchine's and Bernoulli's WLLN, strong law of large numbers, Kolmogorov's theorem. Central limit theorem, De-Moivre's, Lindeberg-Levy, Liapunov CLT.

**Tutorial**
**Credit:1 (Lecture: 15)**

**SUGGESTED READING:**


1. Ash, R.B. and Doléans-Dade, C.A. (1999): Probability and Measure Theory, Second Edition, Academic Press, New York.
2. Basu, A.K. (2004): Measure Theory and Probability, Prentice Hall of India.
3. Bhat, B.R. (1999): Modern Probability Theory, 3rd Edition, New Age International Publishers.
4. Billingsley, P. (2012): Probability and Measure, Anniversary Edition, John Wiley & Sons.
5. Capinski, M. and Zastawniah (2001): Probability through Problems, Springer.
6. Chae, S. B. (1995): Lebesgue Integration, 2nd Edition, Springer Verlag, New York
7. David, S (1996): Elementary Probability, Oxford Press.
8. Edward P.J, Ford J.S. and Lin (1974): Probability for Statistical Decision- Making, Prentice Hall.
9. Feller, W. (1968): An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edition, John Wiley & Sons.
10. Goon A.M., Gupta M.K. Dasgupta B. (1999): Fundamental of Statistics, Vol.II, World Press, Calcutta.
11. Mood A.M, Graybill F.A and Bose D.C (1974): Introduction to the Theory of Statistics, McGraw Hill.
12. Hoel P.G (1971): Introduction to Mathematical Statistics, Asia Publishing House.

**COURSE NAME : Statistical Computing with C and Python**
**COURSE CODE: ST - CE - 8414**
**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 Credits**
**Total Lectures: 45**

**Course Objectives:**

To familiarize the students with

- To understand computer programming and its roles in problem solving.
- To understand basic data structures and develop logic which will help them to create well-structured programs using C language.
- Basic knowledge of Python
- Visualization of statistical data, various measures of descriptive Statistics and statistical analysis using Python

**Course Learning Outcomes:**

After completing this course, students should have developed a clear understanding of:

**CLO – 01:** *Syntax in C to incorporate variables, input/output statement and different operators.*

**CLO – 02**: *Programming elements such as loops, decision making statements, arrays, and strings to solve different mathematical and statistical problems.*

**CLO – 03:** *Basic of Python programming and its application in analysing statistical data.*

**CLO – 04:** *Visualisation of data, calculation of various measures of central tendency as well as dispersion, application of various statistical tools for analysing data using Python*

**Unit- 1: Introduction to C** **(Lectures: 10)**

Basic idea of algorithms and flowcharts, compilers, history and importance of C. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. Data types. Constants and variables: declaration and assignment of variables. Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement operators, precedence of operators in arithmetic, relational and logical expression. Library functions. Managing input and output operations: reading and printing formatted and unformatted data.

**Unit- 2: Decision making and branching** **(Lectures: 12)**

Basics of decision making, if…else, nesting of if…else, else-if-ladder, switch, conditional (?) operator. Looping in C: for, nested for, while, do…while, jumps in and out of loops. Arrays: Declaration and initialization of one-dimensional and two-dimensional arrays. Character arrays and strings: Declaring and initializing string variables, reading, and writing strings from Terminal (using scanf and printf only). Writing simple C programmes for some statistical measures.

**Unit 3: Introduction to Python** **(Lectures: 10)**

Installing Python, Learning Jupyter note book and Spyder, Variable types, mathematical and logical operator, conditional statement...if... Else, Forloop, while loop, Data structure in Python part1 defining: List, tupple, array, set, dictionary, Data structure in Python: operations on Inbuilt methods, Installing and understanding various basic libraries viz. Numpy, Pandas, statsmodel, matplotlib and seaborn , sklearn, Reading file ,writing Files ,merging files, sort, index.

**Unit 4: Visualization Data, Descriptive Statistics and Statistical analysis** **(Lectures: 13)**

Mean, median, Mode, Quartile, percentile, Range, variance, standard deviation, correlation, regression, visualizing the data and interpret summaries for univariate and multi variate data, Scatter plot, Stem and Leaf plot ,Line plot, Bar and pie diagram, Histogram, Box plot. Random number generation, Fitting of suitable distribution : Binomial, Poisson, Normal,One and two sample t-tests for comparing mean, comparing several means using ANOVA, confidence intervals.Chi-Square test,Fitting of polynomials and exponential curves, Linear Regression for two variable, Multiple Regression analysis

**PRACTICAL : 1 Credit**

Total Lectures: 30

List of Practicals:

1. Writing C programmes to find various measures of location: Mean, Median and Mode
2. Writing C programmes to find Partition values
3. Writing C programmes to find various Measures of Dispersion: Range, Variance, Standard Deviation.
4. Writing C programmes to find Correlation and Regression.
5. Computation of Matrix: addition, subtraction, multiplication, transpose, inverse, eigen values and eigen vector using Python
6. Computation of Mean, median, Mode, Quartile, percentile, Range, variance, standard deviation, and correlation from frequency distribution using Python
7. Scatter plot, Stem and Leaf plot ,Line plot, Bar diagram, pie diagram, Histogram and Box plot using Python
8. Fitting of Binomial and Poisson distribution and apply Chi-square test for goodness of fit using Python
9. t-test for difference of means and Paired t-test using Python
10. Contingency table and Chi-square test for independence of attributes using Python
11. ANOVA using Python
12. Fitting of polynomials and exponential curves using Python
13. Linear Regression for two variables and Multiple Regression analysis using Python

**BOOKS RECOMMENDED:**


1. Balagurusamy, E.(2011): Programming in ANSI C,6th Edition,Tata McGraw Hill.
2. Gottfried,B.S.(1998): Schaum's Outlines: Programming with C, 2nd Edition,Tata McGraw Hill
3. Kanetkar,Y. Let us C, 14th edition, BPB publication.
4. Schmuller J.(2025):Statistical Analysis with Python For Dummies, Wiley Publisher

5. Kaganovskiy Leon. (2025): Applied Statistics with Python: Volume I: Introductory Statistics and Regression, Chapman and Hall/CRC.
6. Haslwanter Thomas.(2022): An Introduction to Statistics with Python :With Applications in the Life Sciences (2nd ed.), Springer Publication
7. Pant D and Mukhiya S.K.(2025): Statistics for Data Scientists and Analysts: Statistical approach to data-driven decision making using Python , BPB Publication
8. Zelle John (2024) Python Programming: An Introduction to Computer Science, Franklin, Beedle & Associates INC.

**COURSE NAME: Linear Algebra**
**COURSE CODE: ST - CE -8424**
**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES:**

The objective of the course is to familiarize the students with

- Concepts of Vector space
- Concept of Canonical forms, generalized inverse, Moore – Penrose inverse and Matrix equations.
- Concept of quadratic forms
- Concept of characteristic roots and vectors

**Course Learning Outcomes:**

After completing this course, students should have developed a clear understanding of:

**CLO – 01**: Concepts of linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space, linear space with inner product, orthogonalization of vectors and orthonormal basis of a linear space.

**CLO – 02**: Concepts algebra of matrices, partitioned matrices. Canonical forms, generalized inverse, Moore – Penrose inverse.

**CLO – 03**: Concepts of Quadratic forms, Reduction of quadratic forms, Lagrange's method of transformation of a positive definite quadratic form and Cochran's theorem.

**CLO – 04**: Concepts of Characteristic roots and vectors

**Unit 1: Vector Spaces (Total Lecture: 12)**

Fields, linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space, theory of linear equations. Introduction to Euclidian Space, Inner product, Linear space with inner product, orthogonalization of vectors, orthonormal basis of a linear space.

**Unit 2: Algebra of Matrices (Total Lecture: 10)**

Linear transformation, algebra of matrices, partitioned matrices. Canonical forms, Generalized inverse of a matrix, Different classes of generalized inverse, Properties of g-inverse, Moore – Penrose inverse.

**Unit 3: Characteristic roots and vectors (Total Lecture: 15)**

Characteristic polynomial, characteristic roots, Characteristic vectors, Cayley - Hamilton theorem, Spectral decomposition of matrices – symmetric and asymmetric. Quadratic forms: Reduction of quadratic forms, Lagrange's method of transformation of a positive definite quadratic from, Cochran's theorem.

**Unit 4: Methods of solving Transcendental equations (Total Lecture: 8)**

Graphical method, Bisection method, Regula-Falsi method, Newton-Raphson method.

**Tutorial: (1 Credit)**

**Recommended Books:**


1. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International.
2. Graybill, F.A. (1983). Matrices with applications in statistics, 2nd Ed. Wadsworth.
3. Lipschutz, S. and Lipson, M.L. (2005). Theory and Problems of Linear Algebra, 3rd ed. McGraw Hill Education (India) Private Limited.
4. Rao, C.R. (1973). Linear statistical inference and its applications, 2nd ed. John Wiley and Sons, Inc.
5. Searle, S.R. (1982). Matrix Algebra useful for Statistics. John Wiley and Sons. Inc.

**COURSE NAME: Econometrics**
**COURSE CODE: ST-CE-8434**
**Total credits: 4 (Theory: 3 + Practical: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES:**

This course aims to familiarize students with

- *The concept of econometrics and model building.*
- *The estimation of regression parameters*
- *Hypothesis testing in multiple linear regression*
- *Violation of assumptions in linear models/*

**Course Learning Outcomes:**

After completion of the course, students should have developed a clear understanding of:

**CLO-01**: *Simple linear regression model.*

**CLO-02*:*** *Multiple linear regression model in matrix notation.*

**CLO-03*:*** *Violations of various assumptions under regression analysis viz. multicollinearity, heteroscedasticity, and autocorrelation.*

**CLO-04*:*** *Models of simultaneous relationships between various economic factors.*

**Unit 1: Econometric Models: (Lectures: 10)**

Objective behind building econometric models, nature of econometrics, model building, role of econometrics, relation between variables, Liners models: two or more variables.

**Unit 2: Estimation (Lectures: 10)**

Assumptions of linear model, estimation of regression parameters, tests of significance and confidence intervals.

**Unit 3 : Multiple Regression analysis (Lectures:15)**

Estimation of model parameters, Hypothesis Testing in multiple linear regression, Regression with and without intercept terms, standardized regression coefficients and interpretations, use of $R^2$ and adjusted $R^2$, idea of AIC and BIC.

**Unit 4: Violations of assumptions in linear models (Lectures: 10)**

Problems of multicollinearity, autocorrelation and heteroscedasticity and remedial measures.

**List of Practicals:**

1. Simple linear regression
2. Multiple Linear regression
3. Test for Autocorrelation
4. Test for heteroscedasticity.
5. Test for multicollinearity.
6. Distributed lag models
7. Simultaneous equation models

**Recommended Books:**


1. Greene W.H (2000): Econometric Analysis, 4th Edition, Prentice Hall.
2. Gujarati, D, Porter D. Cand Gunasekar S. (2016): Basic Econometrics, 13th Edition, McGraw Hill Companies.
3. Johnston, J. (1985): Econometric Methods,3rd Edition, McGraw Hill International.
4. Kmenta J (1986): Elements of Econometrics,2nd Edition, Macmillan, New York.
5. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited.
6. Madnani G.M.K (2008): Introduction to Econometrics, Principles and Applications, Oxford & IBH Publishing Co. Pvt Ltd, Delhi.
7. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, Wiley & Sons.
8. Theil H (1971): Principles of Econometrics, John Wiley & Sons Inc, New York

**COURSE NAME: Survival Analysis and Bio-Statistics**
**COURSE CODE: ST-CE-8444**
**Total credits: 4 (Theory: 3 + Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**Course Objectives:** The course objectives are-

- *to introduce concepts and measures used in competing risk theory.*
- *to provide knowledge of survival analysis, censoring, and hazard models.*
- *to acquaint students with epidemiological study designs and analysis methods.*
- *to develop skills for analysing medical and clinical data, including clinical trials.*
- *to introduce the basic concepts and applications of statistical genetics.*

**Course Learning Outcomes:** After completing the course, students will be able to:

**CLO-01**: *Estimate and interpret death probabilities using competing risk models.*
**CLO-02***: Apply survival analysis techniques and fit Cox proportional hazards models.*
**CLO-03***: Design and analyze epidemiological studies and compute key association measures.*
**CLO-04***: Plan and evaluate clinical trials using suitable statistical tools.*
**CLO-05***: Explain basic genetic terminology and apply concepts to biological data.*

**Unit 1: Competing Risk Theory (Lecture: 15)**

Probability of death under competing risks and their inter-relations, Estimation of probabilities of death under competing risks by maximum likelihood and modified minimum Chi-square methods, Theory of independent and dependent risks, Bivariate normal dependent risk model, Conditional death density functions, Idea of DNA sequence.

**Unit 2: Survival Analysis (Lecture: 10)**

Special Survival Features: Censoring and its types. Study time and Patient time, Cox-Proportional Hazards Model: Its Linear Component, Fitting, Hypothesis Tests. Estimating Hazard and Survivor Function. Estimation of Survivor and Hazard Functions: Life table Kaplan Meier Estimates, Incidence, Sample Size Requirements for a Survival Study.

**Unit 3: Epidemiological and clinical data (Lecture: 12)**

Epidemiological study design, Analysis of Medical, Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: Types of studies in Epidemiology and Clinical Research (i) Prospective study (ii) Retrospective study (iii) Cross-sectional study, Expressing

relationship between a risk factor and a disease, Inference for relative risk and odds ratio for 2x2 table, Sensitivity and specificity, Planning and design of clinical trials

**Unit 4: Statistical Genetics (Lecture: 8)**

Introduction, concepts of Genotype, Phenotype, Dominance, Recessiveness, Linkage and Recombination.

**Tutorial: 1 credit**

**Recommended Books:**


1. Biswas, S. (1995). Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
2. Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
3. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
4. Dabholkar A.R. (1999) Elements of Bio Metrical Genetics. Concept Publishing Co., New Delhi.
5. Elandt Johnson R.C. (1971). Probability Models and Statistical Methods in Genetics, John Wiley & Sons.
6. Ewens, W. J. (1979). Mathematics of Population Genetics, Springer Verlag.
7. Ewens, W. J. and Grant, G.R. (2001). Statistical methods in Bio informatics: An Introduction, Springer.
8. Friedman, L.M., Furburg, C. and DeMets, D.L. (1998). Fundamentals of Clinical Trials, Springer Verlag.
9. Gross, A. J. And Clark V.A. (1975). Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.
10. Indrayan, A. (2008). Medical Biostatistics, 2nd ed., Chapman & Hall/CRC.
11. Lee, Elisa, T. (1992). Statistical Methods for Survival Data Analysis, John Wiley & Sons.
12. Li, C.C. (1976). First Course of Population Genetics, Boxwood Press.
13. Liu Xian. (2012) Survival Analysis: Model and Applications. Wiley.
14. Miller, R.G. (1981). Survival Analysis, John Wiley & Sons.

**COURSE NAME: Distribution theory and Simulation**
**COURSE CODE: ST - CE - 8454**
**Total Credits: 4 (Theory: 3 + Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**Course Objective:**

This course aims to familiarize students with-

- *Basic tools of distribution theory*
- *Idea of Censoring and Mixture distributions*
- *Non-central sampling distributions*
- *Idea of simulation*

**Course Learning Outcomes:**

After completion of the course, students should have developed a clear understanding of :

**CLO-1:** The basic tools of distribution theory, function of random variables and their distributions using Jacobian of transformation and other tools.

**CLO-2**: Some basic distributions like Logarithmic, positive and negative multinomial distributions, probability distributions of extremes and its asymptotic distribution.

**CLO-3**: Concept of censoring, truncation and weighted distributions; Mixture distributions and zero modified distributions.

**CLO-4**: Non-central sampling distributions like non-central Chi-square and F distributions and results on other related distributions and proving their properties.

**CLO-5**: Generating random variables from some basic distributions using Congruence method, inverse transform method and acceptance rejection method generation of random variables.

**Unit 1: Distribution Theory (Lectures: 15)**

Basic tools of distribution theory: Joint, marginal and conditional probability mass functions (pmf) and probability density functions (pdf); Moments (raw, central, and factorial) in terms of Stirling numbers; Functions of random variables and their distributions using Jacobian of transformation and other tools. Basic distributions: Logarithmic, positive and negative multinomial, bivariate normal, bivariate exponential and multivariate normal distributions, Probability distributions of extremes and its asymptotic distributions.

**Unit 2: Truncated and Mixture Distribution (Lectures: 10)**

Censoring, Truncation and weighted distributions (use 10 types of weight functions). Truncated Binomial, Poisson, Normal, Cauchy distributions. Intervened Poisson distributions.

Mixture distributions: Definition, finite mixtures, Zero modified distributions with examples, Mixed Poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.

**Unit 3: Sampling Distribution (Lectures: 10)**

Sampling distributions: Non-central chi-square, t, and F distributions their properties and their related distributions.

**Unit 4: Simulation (Lectures: 10)**

Generation of random numbers using congruence method, Evaluation of integrals using random numbers by Monte Carlo approach for single and multiple integrals, Generation of random variables: Inverse transform method, acceptance-rejection method, simulation of discrete random variates by inverse transform method, acceptance-rejection method: Markov Chain Monte Carlo (MCMC).

**Tutorial: (Credit:1)**

**Suggested Readings**


1. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley, Int'l Students' Edition.
2. Johnson, N.L., Kemp, and Kotz, S. 2005, Univariate Discrete Distributions, Wiley, 3rd Ed.
3. Johnson, N.L., Kotz, S. and Balakrishnan, 2004, Multivariate Discrete Distributions, Wiley, 2nd Ed.
4. Johnson, N.L., Kotz, S. and Balakrishnan, 2004, Univariate Continuous Distributions, Wiley, 2nd Ed., Vol. 1 & vol. 2.
5. Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e, Wiley Eastern.
6. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

# MINOR

**Programme Specific Outcome of Bachelor of Science - Statistics Minor**

| PSO No. | Name | Outcome |
|---|---|---|
| PSO–1 | Knowledge and understanding | This course is expected to provide strong foundation Knowledge and understanding of statistics. |
| PSO–2 | Designing Solution | This course helps the students to acquire knowledge of Statistics and trained them to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved. |
| PSO–3 | Critical Thinking | This course helps the students to develop the ability to bring in new ideas, research findings in the areas of real world situations. |
| PSO–4 | Analysis | At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and Statistics. |
| PSO–5 | Applicability in Real World Problem | This course exposes the students to the world of Statistics and its applications in our daily life. |
| PSO–6 | Skill Development | Exposure to a lot of real life data helps in honing their analyzing skills. Moreover, introduction to computer soft - wares helps the students to develop the skills in handling of data by making optimum usage of time and resources. These soft-wares give them the necessary support and an edge when progressing to their professional careers. |
| PSO–7 | Employability | The structure of the course is designed in such a way that it goes a long way in giving students the required impetus and confidence for consultancy startups/jobs in near future. This programme also enables the learners to perform the jobs in diverse fields such as industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations. |

## LIST OF COURSES:

| Semester | Course Name | Course Code |
|---|---|---|
| 1 | Statistical Methods I | ST – MN– 1114 |
| 2 | Basic Probability Theory | ST – MN– 2114 |
| 3 | Applied Statistics | ST – MN – 3214 |
| 4 | Basics Of Statistical Inference | ST – MN – 4214 |
| 5 | Survey Sampling and Indian Official Statistics | ST – MN – 5214 |
| 6 | Econometrics | ST – MN – 6214 |
| 7 | Analysis of Variance and Design of Experiments | ST–MN–7314 |
| 8 | Operations Research | ST–MN–8314 |

**Course Learning Outcome (CLO)**

| Semester | Course Name & Code | Course Learning Outcome (CLO) | |
|---|---|---|---|
| 1 | Statistical Methods I<br>ST – MN – 1114 | CLO - 01 | After completing this course, students should have developed a clear understanding of concepts of statistical population and sample, variables and different scales of measurements. |
| | | CLO - 02 | After completing this course, students should have developed a clear understanding of diagrammatic and graphical presentation of data. |
| | | CLO - 03 | After completing this course, students should have developed a clear understanding of measures of central tendency, dispersion, moments, skewness and kurtosis. |
| | | CLO - 04 | After completing this course, students should have developed a clear understanding of interpolation techniques and numerical integration. |
| | | CLO - 05 | After completing this course, students should have developed a clear understanding of correlation and regression. |
| 2 | Basic Probability Theory<br>ST – MN – 2114 | CLO - 01 | After completing this course, students should have developed a clear understanding of basic probability theory, random experiment, algebra of events, theorems and laws of probability |
| | | CLO - 02 | After completing this course, students should have developed a clear understanding of random variables, their expectations, moments, generating functions and probability functions. |
| | | CLO - 03 | After completing this course, students should have developed a clear understanding of probability inequalities, laws of convergence and applications of law of large numbers. |
| | | CLO - 04 | After completing this course, students should have developed a clear understanding of Important discrete and continuous probability distributions |
| 3 | Applied Statistics<br>ST – MN – 3214 | CLO-01 | After completing this course, students should have developed a clear understanding of time series, its Components, measurement of trend and measurement of seasonal variations |
| | | CLO-02 | After completing this course, students should have developed a clear understanding of index numbers, construction of index numbers of prices and quantities, consumer price index numbers and their uses |

| | | | |
|---|---|---|---|
| 3 | Applied Statistics<br>ST – MN – 3214 | CLO-03 | After completing this course, students should have developed a clear understanding of demographic Methods, measurement of population, measurements of mortality, fertility and population growth |
| | | CLO - 04 | After completing this course, students should have developed a clear understanding of theory of consumption and demand, demand function, elasticity of demand, Lorentz curve, curve of concentration, Engel's law and Engel's curve. |
| 4 | Basics Of Statistical Inference<br>ST – MN – 4214 | CLO-01 | After completing this course, students should have developed a clear understanding ofConcepts of Estimation and its characteristics namely unbiasedness, sufficiency, consistency and efficiency. |
| | | CLO-02 | After completing this course, students should have developed a clear understanding of the basic idea of significance test, testing of hypotheses for the parameters of a normal distribution (one sample) |
| | | CLO-03 | After completing this course, students should have developed a clear understanding of tests of proportions, tests of association and goodness-of-fit using Chi- square test |
| | | CLO-04 | After completing this course, students should have developed a clear understanding of nonparametric tests namely Test of randomness, Sign test for median and Sign test for two samples |
| 5 | Survey Sampling and Indian Official Statistics<br>ST – MN – 5214 | CLO-01 | After completing this course, students should have developed a clear understanding of concepts of non-probability and probability sampling, simple random sampling with and without replacement, procedure of selecting a sample and estimation of population mean, total and proportion in SRS |
| | | CLO-02 | After completing this course, students should have developed a clear understanding of Concepts of stratified random sampling along with estimation of population mean and total in these methods, Brief idea about Systematic Sampling |
| | | CLO-03 | After completing this course, students should have developed a clear understanding ofconcept of Ratio and Regression Method of Sampling and Cluster sampling |
| | | CLO - 04 | After completing this course, students should have developed a clear understanding of knowledge about Indian official Statistics |
| 6 | Econometrics<br>ST – MN - 6214 | CLO-01 | After completing this course, students should have developed a clear understanding ofconcepts of objective behind building econometric models and linear models for two variables. |

| | | | |
|---|---|---|---|
| 6 | Econometrics<br>ST-MN-6214 | CLO-02 | After completing this course, students should have developed a clear understanding of concepts of Least square assumptions of regression models for two variables and estimation of regression parameters |
| | | CLO-03 | After completing this course, students should have developed a clear understanding of concept of multiple Regression analysis. |
| | | CLO-04 | After completing this course, students should have developed a clear understanding of concepts of Multicollinearity, Autocorrelation and heteroscedasticity |
| 7 | Design of Experiments<br>ST-MN-7314 | CLO-01 | After completing this course, students should have developed a clear understanding of Understand and analyse statistical data by using analysis of variance (AoV). |
| | | CLO-02 | After completing this course, students should have developed a clear understanding of Understand the principles used in design of experiments, Basic designs such as CRD, RBD, LSD, Split Plot Design. |
| | | CLO-03 | After completing this course, students should have developed a clear understanding of analyse basic designs with one missing observation. |
| | | CLO-04 | After completing this course, students should have developed a clear understanding of Understand and analyse multifactor experiments viz.2n (n=2,3) factorial experiments with total and partial confounding. |
| 8 | Operations Research<br>ST-MN-8314 | CLO-01 | After completing this course, students should have developed a clear understanding of gain knowledge of operations research, building mathematical models, techniques constructively and solving them to make effective decisions making. |
| | | CLO-02 | After completing this course, students should have developed a clear understanding of develop the ability to model real-world problems as linear programming problems, understand their constraints and objectives, and apply the simplex method for optimization. |
| | | CLO-03 | After completing this course, students should have developed a clear understanding of acquire practical skills in solving transportation problems, including initial solutions using various methods like North West corner rule, least cost method, and Vogel's approximation method. |
| | | CLO-04 | After completing this course, students should have developed a clear understanding of implement the theory of Game in real life situation and solution of game having mixed strategy. |
| | | CLO-05 | After completing this course, students should have developed a clear understanding of Understand the importance of resource allocation in case of inventory management. Develop a solid understanding of optimal inventory policy for EOQ model and its variations. |

## MAPPING OF PROGRAMME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO):

**Attributes:** Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

| Course Code | CLO | Programme Outcome (SPO) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO-1 | SPO-2 | SPO-3 | SPO-4 | SPO-5 | SPO-6 | SPO-7 | SPO-8 | SPO-9 | SPO-10 | SPO-11 |
| ST-MN-1114 | CLO-1 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 3 | 2 |
| | CLO-2 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CLO - 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO - 4 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CLO - 5 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| ST-MN-2114 | CLO-1 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 |
| | CLO - 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 2 |
| | CLO - 4 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| ST-MN-3214 | CLO-1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO-2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO - 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CLO - 4 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 |
| ST-MN-4214 | CLO-1 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 |
| | CLO-2 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 |
| | CLO - 3 | 3 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3 |
| | CLO - 4 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 3 |
| ST-MN-5214 | CLO-1 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 3 | 3 |
| | CLO-2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 2 | 3 |
| | CLO - 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 |
| | CLO - 4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| ST-MN-6214 | CLO-1 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 3 |
| | CLO-2 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 |
| | CLO - 3 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 3 |
| | CLO - 4 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 3 |
| ST-MN-7314 | CLO1 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO2 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 |
| | CLO3 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 2 |
| | CLO4 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 2 |
| ST-MN-8314 | CLO1 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CLO2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 |
| | CLO3 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 2 | 3 | 2 |
| | CLO4 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 2 |

## MAPPING OF PROGRAMME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOME (CLO)

**Attributes:** Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

| Course Code | CLO | PROGRAMME SPECIFIC OUTCOME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PSO-1 | PSO-2 | PSO-3 | PSO-4 | PSO-5 | PSO-6 | PSO - 7 |
| ST-MN-1114 | CLO-1 | 3 | | | | 1 | 3 | |
| | CLO-2 | 3 | | | | 2 | 3 | |
| | CLO - 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO - 4 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO - 5 | 3 | 2 | 2 | 2 | 3 | 3 | 2 |
| ST-MN-2114 | CLO-1 | 3 | 2 | | 3 | 2 | 3 | 2 |
| | CLO-2 | 3 | 2 | 1 | 3 | 2 | 3 | 2 |
| | CLO - 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO - 4 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| ST-MN-3214 | CLO-1 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO - 3 | 3 | 2 | 1 | 2 | 3 | 3 | 2 |
| | CLO - 4 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| ST-MN-4214 | CLO-1 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO-2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO - 3 | 3 | 2 | 3 | 2 | 2 | 3 | 2 |
| | CLO - 4 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| ST-MN-5214 | CLO-1 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| | CLO-2 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO - 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO - 4 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| ST-MN-6214 | CLO-1 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |
| | CLO-2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO - 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 |
| | CLO - 4 | 3 | 2 | 2 | 3 | 2 | 3 | 2 |

| Course Code | CLO | PROGRAMME SPECIFIC OUTCOME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | PSO-1 | PSO-2 | PSO-3 | PSO-4 | PSO-5 | PSO-6 | PSO - 7 |
| ST-MN-7314 | CLO1 | 3 | 2 | 2 | 3 | 2 | 1 | 1 |
| | CLO2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 |
| | CLO3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| | CLO4 | 2 | 1 | 1 | 1 | 1 | 2 | 1 |
| ST-MN-8314 | CLO1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| | CLO2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 |
| | CLO3 | 3 | 2 | 3 | 2 | 2 | 2 | 1 |
| | CLO4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |

**COURSE NAME: Statistical Methods**

**COURSE CODE: ST – MN – 1114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVE:**

*The course objectives are as follows:*

- *To summarize the mass of data, to extract salient features from it and interpretation of results.*
- *To understand the concept of interpolation and numerical integration.*
- *To understand the concept of relationship between two variables.*

**Course Learning Outcome:**

*On completion of this course, students are expected to have a clear understanding of:*

**CLO-01:** *Concepts of statistical population and sample, variables and different scales of measurements.*

**CLO -02:** *Diagrammatic and graphical presentation of data.*

**CLO -03:** *Measures of central tendency, Dispersion, Moments, Skewness and Kurtosis.*

**CLO -04:** *Interpolation techniques and Numerical Integration*

**CLO -05:** *Correlation and Regression.*

**Unit 1: Statistical Data (Lectures:10)**

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: Univariate Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic. Indian Knowledge System (IKS): Idea of IKS, Use of Statistics in Ancient India.

**Unit 2: Descriptive Statistics (Lectures: 15)**

Measures of Central Tendency: AM, GM, HM, Median and Mode. Partition Values: Quartiles, Deciles and Percentiles. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

**Unit 3: Calculus of Finite Difference (Lectures:10)**

Finite Difference: Definition, Operators $\Delta$ & E, their properties, Difference table, missing terms, Interpolation: Definition, Newton's Forward and Backward interpolation formula, Lagrange's interpolation formula. Numerical Integration: Introduction, General quadrature formula, Trapezoidal, Simpson's 1/3rd & 3/8th rules.

**Unit 4**: **Bivariate Data (Lectures: 10)**

Bivariate data: Definition, scatter diagram, simple correlation, principle of least squares, Simple linear regression

**PRACTICAL**

**Total Lectures: 30**

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Correlation coefficient for a bivariate frequency distribution
9. Lines of regression, angle between lines and estimated values of variables.
10. Problems based on Newton's Forward and Backward interpolation formula.
11. Problems based on Lagrange's interpolation formula.

**BOOKS RECOMMENDED:**


1. Choudhury, L: An Introduction to Statistics, Kitab Ghar
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
3. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics,11th Edition. Sultan Chand and Sons, New Delhi.
4. Gupta P.P, Malik G.S. and Gupta S., (2006), Calculus of Finite Differences and Numerical Analysis, 34th Edn, Krishna Prakashan Media (P) Ltd, Meerut.
5. Agarwal, B. (2007c). *Programmed Statistics (Question-Answers)*. New Age International.
6. Yule, G.U. (1911). An Introduction to the Theory of Statistics. Journal of the Royal Statistical Society, 101(1), 225.

**COURSE NAME: Basic Probability Theory**

**COURSE CODE: ST – MN – 2114**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY: 3 Credits**

**TOTAL LECTURES: 45**

**COURSE OBJECTIVE:**

*To familiarize the students with the:*

- *Concept of Probability theory, different laws and events and related theorems.*
- *Concept of random variables, Mathematical expectation, p.m.f, p.d.f. and generating functions.*
- *Idea of convergence in probability.*
- *Different standard probability distributions for both discrete and continuous random variables*

**Course Learning Outcome:**

*On completion of this course, students are expected to have a clear understanding of:*

**CLO - 01:** *Basic probability theory, random experiment, algebra of events, theorems and laws of probability*

**CLO - 02:** *Random variables, their expectations, moments, generating functions and probability functions.*

**CLO - 03:** *Probability inequalities, Laws of convergence and applications of law of large numbers.*

**CLO - 04:** *Important Discrete and continuous probability distributions.*

**Unit 1: Probability (Lectures: 15)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability and Bayes' theorem.

**Unit 2: Random Variables and Mathematical Expectation (Lectures: 10)**

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. Illustrations of random variables and its properties. Expectation, variance and moment generating function.

**Unit 3: Convergence in Probability (Lectures: 10)**

Idea of convergence in probability, Chebyshev's inequality, weak law of large numbers, De-

Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.) (statement only without proof).

**Unit 4: Standard Probability Distributions (Lectures: 10)**

Standard probability distributions: Bernoulli, Binomial, Poisson, Normal.

**PRACTICAL**

**Total Lectures: 30**

1. Fitting of binomial distributions for n and p = q = 1/2 given
2. Fitting of binomial distributions for n and p given
3. Fitting of binomial distributions computing mean and variance
4. Fitting of Poisson distributions for given value of lambda
5. Fitting of Poisson distributions after computing mean
6. Application problems based on binomial distribution
7. Application problems based on Poisson distribution
8. Fitting of normal distribution.

**BOOKS RECOMMENDED:**


1. Feller, W. (1968b). *An Introduction to Probability Theory and Its Applications: Volume I*. John Wiley & Sons.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata
3. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics, 11thEdn. Sultan Chand and Sons, New Delhi.
4. Gupta O.P., Chaudhary S.S. Applied Statistics: Kedar Nath Ram Nath
5. Mood, A. M., & Graybill, F.A. (1911). An Introduction to the Theory of Statistics. Nature, 87(2185), 345.

**COURSE NAME: Applied Statistics**

**COURSE CODE: ST - MN - 3214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

**Course Objectives:**

*To familiarize the students with*

- *The concepts of time series analysis and its applications.*
- *The concepts of index number and its uses.*
- *The concepts of Demography, measurements of mortality, fertility and population growth*
- *The concepts of demand analysis and its applications.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Time series, its Components, measurement of trend and measurement of seasonal variations*

**CLO – 02:** *Index numbers, construction of index numbers of prices and quantities, consumer price index numbers and their uses*

**CLO – 03:** *Demographic Methods, measurement of population, measurements of mortality, fertility and population growth.*

**CLO – 04**: *Theory of consumption and demand, demand function, elasticity of demand, Lorentz curve, curve of concentration, Engel's law and Engel's curve*.

**Unit 1: Time series analysis** (Lectures: 12)

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential), method of Moving averages. Measurement of seasonal variations by method of ratio to trend.

**Unit 2: Index number** (Lectures: 13)

Index numbers: Definition, Construction of index numbers of prices and quantities, different types of index numbers, tests of Index number, consumer price index number, uses and limitations of index numbers.

**Unit 3: Demography** (Lectures: 10)

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates. Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

**Unit 4: Demand Analysis:** (Lectures: 10)

Demand Analysis: Theory of consumption and demand, demand function, elasticity of demand, determination of elasticity of demand by family budget method, Lorentz curve, curve of concentration, Engel's law and Engel's curve.

**PRACTICAL**

**Total Lectures: 30**

**List of Experiments**

1 Measurement of trend: Fitting of linear, quadratic trend, exponential curveand plotting of trend values and comparing with given data graphically.

2 Measurement of seasonal indices by Ratio-to-trend method and plotting oftrend values and comparing with given data graphically.

3 Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.

4 Construction of wholesale price index number, fixed base indexnumber and consumer price index number with interpretation

5 Computation of measures of mortality

6 Completion of life table

7 Computation of measures of fertility and population growth

**BOOKS RECOMMENDED:**


1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, 4th Edition (Reprint), Sultan Chand and Sons
4. Gupta O.P, Chaudhary S.S. Applied Statistics: Kedar Nath Ram Nath
5. Elhance, D. N., & Elhance, V. (1988). Fundamentals of Statistics: Containing 750 Fully Solved and 1250 Problems for Review Exercises with Answers.

**COURSE NAME: Basics of Statistical Inference**

**COURSE CODE: ST - MN - 4214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 45**

**Course Objectives:**

*To familiarize the students with*

- *The concepts of estimation*
- *The concepts of testing of hypothesis*
- *The concepts of categorical data analysis*
- *The concepts of non-parametric tests.*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of Estimation and its characteristics namely unbiasedness, sufficiency, consistency and efficiency*

**CLO – 02**: *The basic idea of significance test, testing of hypotheses for the parameters of a normal distribution (one sample)*

**CLO – 03**: *Tests of proportions, tests of association and goodness-of-fit using Chi- square test*

**CLO – 04**: *Nonparametric tests namely Test of randomness, Sign test for median and Sign test for two samples*

**Unit 1: Estimation:** (Lecture: 10)

Concepts of Estimation, unbiasedness, sufficiency, consistency and efficiency.

**Unit 2: Tests of Hypothesis:** (Lectures: 10)

The basic idea of significance test. Null and alternative hypothesis. Type I and Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample)

**Unit 3: Categorical Data Analysis:** (Lectures: 15)

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chi- square test, Yates' correction.

**Unit 4**: **Non-parametric tests:** (Lectures: 10)

Test of randomness, Sign test for median, Sign test for two samples

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample).
3. Tests of hypotheses for the parameters of a normal distribution (one sample).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient. B.Sc. Honours (Statistics) 49
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.

**BOOKS RECOMMENDED:**


1. Biswas, S. (1988): Stochastic Processes in Demography and Application, Wiley Eastern Ltd.
2. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
3. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
4. Gupta O.P, Chaudhary S.S. Applied Statistics: Kedar Nath Ram Nath
5. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New York.
6. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.

**COURSE NAME: Survey Sampling and Indian Official Statistics**

**COURSE CODE: ST - MN - 5214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objectives:**

*To familiarize the students with*

- *Concepts of simple random sampling with and without replacement.*
- *Concept of stratified random sampling and Systematic Sampling.*
- *Concept of Ratio and Regression Methods of Sampling and Cluster sampling.*
- *Knowledge of Indian official Statistics*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of non-probability and probability sampling, simple random sampling with and without replacement, procedure of selecting a sample and estimation of population mean, total and proportion in SRS*

**CLO – 02**: *Concepts of stratified random sampling along with estimation of population mean and total in these methods, Brief idea about Systematic Sampling*

**CLO – 03**: *Concept of Ratio and Regression Method of Sampling and Cluster sampling*

**CLO – 04:** *Knowledge about Indian official Statistics*

**Unit 1: Survey Sampling: (Lectures: 15)**

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Indian Knowledge System (IKS): Use of Sample survey techniques in Ancient India.

Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean and total.

**Unit 2: Stratified Random sampling: (Lectures: 12)**

Estimates of population mean and total, variances of these estimates, proportional and optimum allocations and their comparison with SRS. Idea of Systematic Sampling.

**Unit 3: Ratio and Regression Method of Sampling: (Lectures: 10)**

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size). Cluster sampling (equal clusters only) estimation of population mean and its variance.

**Unit 4: Official Statistics: (Lectures: 8)**

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics and Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals**

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.

**BOOKS RECOMMENDED:**


1. Cochran, W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern.
2. Sukhatme, P.V., Sukhatme, B.V. Sukhatme, S. Asok, C. (1984). Sampling Theories of Survey with Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy, M.N. (1977): Sampling Theory and Statistical Methods, Statistical Pub. Society, Calcutta.

4. Des Raj and Chandhok, P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Goon, A.M., Gupta, M.K. and Das Gupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi

**COURSE NAME: Econometrics**

**COURSE CODE: ST - MN - 6214**

**Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)**

**THEORY**

**Total Lectures: 45**

**Course Objective:**

*To familiarize the students with*

- *Concepts of Linear Models.*
- *Concept of estimation of regression parameters of linear models for two variables.*
- *Concept of multiple Regression analysis.*
- *Concepts of Multi collinearity and Autocorrelation*

**Course Learning Outcome:**

*After completing this course, students should have developed a clear understanding of:*

**CLO – 01**: *Concepts of objective behind building econometric models and linear models for two variables.*

**CLO – 02**: *Concepts of Least square assumptions of regression models for two variables and estimation of regression parameters*

**CLO – 03:** *Concept of multiple Regression analysis.*

**CLO – 04:** *Concepts of Multicollinearity, Autocorrelation and heteroscedasticity*

**Unit 1: Linear Models: (Lectures: 12)**

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, linear models for two variables.

**Unit 2: Estimation: (Lectures: 13)**

Least square assumptions, estimation of regression parameters, tests of significance and confidence intervals.

**Unit 3: Regression: (Lectures: 10)**

Multiple Regression analysis, estimation and inference.

**Unit 4: Multicollinearity and Autocorrelation: (Lectures: 10)**

Violations of Least Square assumptions: multicollinearity, autocorrelation and heteroscedasticity.

**PRACTICAL**

**Total Lectures: 30**

**List of Practicals:**

1. Problems based on estimation of General linear model.
2. Testing of parameters of General linear model.
3. Forecasting of General linear model.
4. Problems related to: consequences of Multicollinearity.
5. Problems related to: consequences of Autocorrelation.
6. Estimation of problems of General linear model.

**BOOKS RECOMMENDED:**


1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies.
2. Johnston, J. (1972): Econometric Methods, 2nd Edition, McGraw Hill International.
3. Koutsoyiannis, A. (2004): Theory of Econometrics, 2nd Edition, Palgrave Macmillan Limited,
4. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, John Wiley and Sons.
5. Baltagi, B. H. (2007). Econometrics. Springer Science & Business Media.
6. Singh, S.P. (1999). Econometrics and Mathematical Economics. S.Chand

**COURSE NAME: Design of Experiments**

**COURSE CODE: ST-MN-7314**

**Total Credits: 4 (Theory: 3 + Practical: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**COURSE OBJECTIVES:**

The learning objectives include developing a clear understanding of

- *the fundamental concepts of analysis of variance*
- *analysis of basic design of experiments*
- *factorial experiments including confounding*
- *split plot and strip plot design*

## Course Learning Outcomes:

After completing the course, students are expected to have a clear understanding of :

**CLO-01**: *Understand and analyse statistical data by using analysis of variance (AoV).*

**CLO-02:** *Understand the principles used in design of experiments, Basic designs such as CRD, RBD, LSD, Split Plot Design.*

**CLO-03:** *Analyse basic designs with one missing observation.*

**CLO-04:** *Understand and analyse multifactor experiments viz.* $2^n$ *(n=2,3) factorial experiments with total and partial confounding.*

**Unit 1**: **Analysis of variance and Design of experiments (Lectures:10)**

Idea of Analysis of variance (AoV), Analysis of AoV- One way classification and Two-way classification, choice of size and shape of plots and blocks, Idea of Design of experiments, Basic principles of Design of experiment.

**Unit 2**: **Analysis of Basic Design of Experiments (Lectures: 15)**

Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.

**Unit 3: Factorial Experiments (Lectures:15)**

Factorial experiments: advantages, notations and concepts, $2^2$ and $2^3$ factorial experiments, design and analysis, Total and Partial confounding for $2^n$ ($n \leq 3$).

**Unit 4: Split Plot Design: (Lectures: 5)**

Idea of Split Plot Design and Strip Plot Design.

**Practical : Credit:1(Total Lectures: 30)**

**List of Practicals**

1. Analysis of Variance: One way Classification
2. Analysis of Variance: Two way Classification
3. Analysis of a CRD
4. Analysis of an RBD
5. Analysis of an LSD
6. Analysis of an RBD with one missing observation
7. Analysis of $2^2$ and $2^3$ factorial in CRD and RBD
8. Analysis of a completely confounded two level factorial design
9. Analysis of a partially confounded two level factorial design.

**Recommended Books:**


1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol.II, 8th Edn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D.C. (2008): Design and Analysis of Experiments, John Wiley.

**Course Name: Operations Research**

**Course Code: ST-MN-8314**

**Total Credits: 4 (Theory: 3 + Practical: 1)**

**THEORY: 3 CREDITS**

**Total Lectures: 45**

**Course Objectives:** The course objectives of this course are to:

- *Familiarize students with the fundamental concepts of Operations Research (O.R.) and its various phases.*
- *Develop a strong foundation in linear programming (LP) by learning the mathematical formulation of LP problems and graphical solutions.*
- *Learn optimization techniques for solving transportation problems, including initial solutions using various methods like North West corner rule, Least cost method, and Vogel's approximation method.*
- *Understand the principles of game theory, including rectangular games, minimax- maximin principles, and solution methods using graphical approaches.*
- *Understand the concept of inventory management system*

**Course Learning Outcomes**:

After successful completion of this course, student will be able to:

**CLO-01**: Gain knowledge of operations research, building mathematical models, techniques constructively and solving them to make effective decisions making.

**CLO-02:** Develop the ability to model real-world problems as linear programming problems, understand their constraints and objectives, and apply the simplex method for optimization

**CLO-03**: Acquire practical skills insolving transportation problems, including initial solutions using various methods like North West corner rule, least cost method, and Vogel's approximation method.

**CLO-04**: Implement the theory of Game in real life situation and solution of game having mixed strategy.

**CLO-05**: Understand the importance of resource allocation in case of inventory management. Develop a solid understanding of optimal inventory policy for EOQ model and its variations.

**UNIT 1:** Introduction to Operations Research **(Lectures: 15)**

Different phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. involving artificial variables.

**UNIT 2: Transportation Problem (Lectures: 10)**

Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM)

**UNIT 3: Game theory (Lectures: 10)**

Rectangular game, minimax- maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution of $2 \times 2$rectangular game with mixed strategy.

**UNIT 4: Inventory Management (Lectures: 10)**

ABC inventory system, characteristics of inventory system. EOQ Model and its variations- without shortages, quantity discounts model with price breaks

**PRACTICAL**

**List of Practicals:**

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique
2. Identify the following Special cases by Graphical and Simplex method
    - Degenerate solution
    - Unbounded solution
    - Infeasible solution
3. Allocation problem using Transportation model
4. Problems based on game matrix
    - Graphical solution to $m \times 2$, $2 \times n$, $2 \times 2$ rectangular game
    - Mixed strategy
5. To find optimal inventory policy for EOQ models and its variations

**Recommended Books:**


1. Hadley, G: (2002): Linear Programming, Narosa Publications
2. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill
3. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
4. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.

# SKILL ENHANCEMENT COURSE (SEC)

**Programme Specific Outcome of Bachelor of Science - Skill Enhancement Course**

| PSO No. | Name | Outcome |
|---|---|---|
| PSO–1 | Knowledge and understanding | This course is expected to provide strong foundation Knowledge and understanding of statistics. |
| PSO–2 | Analysis | At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and Statistics. |
| PSO–3 | Skill Development | Exposure to a lot of real-life data helps in honing their analyzing skills. Moreover, introduction to computer soft - wares helps the students to develop the skills in handling of data by making optimum usage of time and resources. These soft-wares give them the necessary support and an edge when progressing to their professional careers. |
| PSO–4 | Employability | The structure of the course is designed in such a way that it goes a long way in giving students the required impetus and confidence for consultancy startups/jobs in near future. This programme also enables the learners to perform the jobs in diverse fields such as industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations. |

**Basic Syllabus Structure of SEC**

| Semester | Course Name | Course code |
|---|---|---|
| 1 | Statistical Analysis Using Microsoft EXCEL | ST – SE – 1113 |
| 2 | Statistical Analysis Using SPSS | ST – SE – 2113 |
| 3 | Statistical Analysis Using R | ST – SE – 3213 |

## COURSE LEARNING OUTCOME – SKILL ENHANCEMENT COURSE (SEC)

| Semester | Course Name & Code | Course Learning Outcome (CLO) | |
|---|---|---|---|
| 1 | Statistical Analysis Using Microsoft EXCEL ST-SE-1113 | CLO-01 | After completing this course, the students will acquire the skill for presenting data diagrammatically and graphically, Interpreting graphs and diagrams |
| | | CLO-02 | After completing this course, the students will acquire the skill for Summarizing data using descriptive measures |
| | | CLO-03 | After completing this course, the students will acquire the skill for Understanding relationship between variables and testing significance of the relationships |
| 2 | Statistical Analysis Using SPSS ST-SE-2113 | CLO-01 | After the successful completion of this course, to plot graphs and diagrams, interpret them |
| | | CLO-02 | After the successful completion of this course, to carry out simple correlation and regression analysis and to plot different curves in SPSS |
| | | CLO-03 | After the successful completion of this course, students will be able to learn use of parametric as well as non-parametric tests and also to write simple project reports using statistical tools in SPSS |
| 3 | Statistical Analysis Using R ST-SE-3213 | CLO-01 | After the successful completion of this course, students will be able to present data diagrammatically and graphically, interpreting graphs and diagrams. |
| | | CLO-02 | After the successful completion of this course, students will be able to summarizing data using descriptive measures |
| | | CLO-03 | After the successful completion of this course, students will be able to apply different types of Statistical tests to analyse data. |

## MAPPING OF COURSE LEARNING OUTCOME AND PROGRAMME OUTCOME

| Course Code | CLO | PROGRAMME OUTCOME | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO-1 | SPO-2 | SPO-3 | SPO-4 | SPO-5 | SPO-6 | SPO-7 | SPO-8 | SPO-9 | SPO-10 | SPO-11 |
| ST-SE-1113 | CLO1 | 3 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CLO 2 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CLO 3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| ST-SE-2113 | CLO1 | 3 | 1 | 2 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |
| | CLO 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |
| | CLO 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |
| ST-SE-3213 | CLO1 | 3 | 1 | 2 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |
| | CLO 2 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |
| | CLO 3 | 3 | 3 | | 3 | 1 | 3 | 2 | 2 | 3 | 2 | 3 |

## MAPPING OF COURSE LEARNING OUTCOME AND PROGRAMME SPECIFIC OUTCOME

| Course code | CLO | Programme Specific Outcome | | | |
|---|---|---|---|---|---|
| | | PSO-1 | PSO-2 | PSO-3 | PSO-4 |
| ST-SE-1113 | CLO 1 | 3 | 1 | 3 | 2 |
| | CLO 2 | 3 | 3 | 3 | 2 |
| | CLO 3 | 3 | 3 | 3 | 2 |
| ST-SE-2113 | CLO 1 | 3 | 1 | 3 | 3 |
| | CLO 2 | 3 | 3 | 3 | 3 |
| | CLO 3 | 3 | 3 | 3 | 3 |
| ST-SE-3213 | CLO 1 | 3 | 1 | 3 | 3 |
| | CLO 2 | 3 | 3 | 3 | 3 |
| | CLO 3 | 3 | 3 | 3 | 3 |

**COURSE NAME: Statistical Analysis Using Microsoft EXCEL**

**COURSE CODE: ST - SE - 1113**

**Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)**

## THEORY

**Total Lectures: 30**

**Course Objective:**

*The course objectives are as follows:*

- *To give a preliminary idea of Diagrammatic and Graphical Representation of Statistical data using Excel.*
- *To give them idea of measures of central tendency, dispersion, skewness and kurtosis.*
- *To handle bivariate data and test more than two means at a time.*

**Course Learning Outcome:**

*After completing this course, the students will acquire the skill for*

**CLO – 01:** *Presenting data diagrammatically and graphically, interpreting graphs and diagrams.*

**CLO – 02:** *Summarizing data using descriptive measures.*

**CLO – 03:** *Understanding relationship between variables and testing significance of the relationships*

**Unit 1: Diagrammatic and Graphical Representations (Lectures: 10)**

Diagrammatic representation: Bar diagram, scatter diagram, pie diagram, graphical representation: histogram, box plot, frequency polygon and frequency curve, Pivot Tables, Normal probability plot.

**Unit 2: Descriptive Statistics: (Lectures:10)**

Descriptive statistics: Mean, Standard Error, Median, Mode, Standard Deviation, Sample variance, Range, Skewness, Kurtosis

**Unit 3: Analysis (Lectures: 10)**

t, F, Chi-square, ANOVA (Analysis of Variance), correlation and lines of regression, p-values and confidence intervals

## PRACTICAL

**Total Lectures: 30**

Related to above topics

**BOOKS RECOMMENDED**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & Vol. II 8th Edn. The World Press, Kolkata.
2. McFedries, P. (2022). Excel Data Analysis for Dummies. John Wiley &Sons.
3. Agarwal, B. (2007c). Programmed Statistics (Question-Answers). New Age International.
4. Yule, G.U. (1911). An Introduction to the Theory of Statistics. Journal of the Royal Statistical Society, 101(1),225.
5. Winston, W.L. (2014). Marketing Analytics: Data Driven Techniques with Microsoft Excel. John Wiley & Sons.
6. Guerrero, H. (2018). Excel Data Analysis: Modeling and Simulation. Springer.

## COURSE NAME: Statistical Analysis Using SPSS

## COURSE CODE: ST-SE-2113

## Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

**THEORY**

**Total Lectures: 30**

**Course Objectives:**

*The course objectives are as follows:*

- *To give idea of Graphical Representation of Statistical data using SPSS.*
- *To give knowledge for analysis of bivariate data, fitting of curves using SPSS.*
- *To give idea for preparing project report using SPSS.*

**Course Learning Outcome:**

*On completion of this course, students will be able:*

**CLO – 01:** *To plot graphs and diagrams, interpret them.*

**CLO – 02:** *To carry out simple correlation and regression analysis and to plot different curves in SPSS.*

**CLO – 03:** *To learn use of parametric as well as non-parametric tests and also to write simple project reports using statistical tools in SPSS*

**Unit 1: Introduction to SPSS (Lectures: 10)**

Creating SPSS file, defining variables, selecting and sorting cases, computing and recoding variables, import and export of data, summarizing data- Frequency distribution, custom tables, cross-tabulation, descriptive statistics- measures of location and dispersion, partition values, skewness and kurtosis, correlation and regression, Random number generation.

**Unit 2: Graphical Representation (Lectures: 10)**

Plotting Graphs: bar diagram- simple, sub-divided, multiple, box plot, pie chart, histogram, frequency polygon, ogive, Fitting of polynomials and exponential curves

**Unit 3: Parametric and Non-Parametric Tests (Lectures: 10)**

Parametric Tests: Comparing means: One and two sample t-tests, comparing several means using ANOVA. Non-Parametric Tests: Chi-Square test of independence of attributes and goodness of fit, One-sample Kolmogorov Smirnov Test.

**PRACTICAL**

**Total Lectures: 30**

Related to above topics

**BOOKS RECOMMENDED**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & Vol. II 8th Edn. The World Press, Kolkata
2. Moore, D.S. and McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H. Freeman
3. Cunningham, J.B., & Aldrich, J.O. (2012). Using SPSS: An Interactive Hands-On Approach. SAGE.
4. Salcedo, J., & McCormick, K. (2020). SPSS Statistics for Dummies. John Wiley & Sons.
5. MacInnes, J. (2016). An Introduction to Secondary Data Analysis with IBM SPSS Statistics. University of Edinburgh
6. Field, A. (2009). Discovering statistics using SPSS (3rd ed.). SAGE Publications.
7. Cleff, T. (2013). Exploratory Data Analysis in Business and Economics: An Introduction Using SPSS, Stata, and Excel. Springer Science & Business Media.

## COURSE NAME: Statistical Analysis using R

## COURSE CODE: ST-SE-3213

## Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

**THEORY**

**Total Lectures: 30**

**Course Objectives:**

*The course objectives are as follows:*

- *To give a preliminary idea of Diagrammatic and Graphical Representation of Statistical data using R.*
- *To give them idea of measures of central tendency, dispersion, correlation and regression using R*
- *To handle Statistical Analysis using R*

**Course Learning Outcome:**

*After the successful completion of this course, students will be able to:*

**CLO – 01**: *Present data diagrammatically and graphically, interpreting graphs and diagrams.*

**CLO – 02:** *Summarizing data using descriptive measures.*

**CLO – 03:** *Apply different types of Statistical tests to analyze data.*

**Unit 1: Diagrammatic and Graphical Representations: (Lectures: 10)**

Learn how to load data, import data, Diagrammatic representation: Bar diagram, scatter diagram, pie diagram, graphical representation: histogram, box plot, frequency polygon and frequency curve, Normal probability plot.

**Unit 2: Descriptive Statistics: (Lectures: 10)**

Descriptive statistics: Mean, Median, Mode, quartiles, Standard Deviation, variance, Range, correlation and lines of regression.

**Unit 3: Statistical Analysis: (Lectures: 10)**

Random number generation and sampling procedures. Fitting of polynomials, fitting of suitable distribution, t, F, Chi-square tests, ANOVA (Analysis of Variance), p-values and confidence intervals

**PRACTICAL**

**Total Lectures: 30**

Related to above topics

**BOOKS RECOMMENDED**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I& Vol. II 8$^{th}$Edn. The World Press, Kolkata.
2. Gardener, M (2012) Beginning R: The Statistical Programming Language, Wiley Publications.
3. Braun W J, Murdoch D J (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York

# INTER-DISCIPLINARY COURSE (IDC)

**Programme Specific Outcome of Bachelor of Science - IDC**

| PSO No. | Name | Outcome |
|---|---|---|
| PSO–1 | Knowledge and understanding | This course is expected to provide strong foundation Knowledge and understanding of statistics. |
| PSO–2 | Analysis | At the end of the program, students will be able to identify, formulate and analyze scientific problems and reach concrete solutions using various principles of mathematics and Statistics. |
| PSO–3 | Applicability in Real World Problem | This course exposes the students to the world of Statistics and its applications in our daily life. |
| PSO–4 | Employability | The structure of the course is designed in such a way that it goes a long way in giving students the required impetus and confidence for consultancy startups/jobs in near future. This programme also enables the learners to perform the jobs in diverse fields such as industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations. |

**Basic Syllabus Structure of IDC**

| Semester | Course Name | Course Code |
|---|---|---|
| 1 | Basic Statistics | ST-ID-1113 |
| 2 | Applied Statistics | ST-ID-2113 |
| 3 | Basic Probability Theory | ST-ID-3213 |

**Course Learning Outcome (CLO)**

| Semester | Course Name & Code | Course Learning Outcome (CLO) | |
|---|---|---|---|
| 1 | Basic Statistics<br>ST-ID-1113 | CLO-01 | After completing this course, the students should have developed a clear understanding of concepts of statistical population and sample, variables. |
| | | CLO-02 | After completing this course, the students should have developed a clear understanding of diagrammatic and graphical presentation of data. |
| | | CLO - 03 | After completing this course, the students should have developed a clear understanding of measures of central tendency, Dispersion and bivariate data |
| 2 | Applied Statistics<br>ST-ID-2113 | CLO-01 | On completion of this course, students are expected to have a understanding of population and sample, A few basic methods of Sampling. |
| | | CLO-02 | On completion of this course, students are expected to have a understanding of definition and constructions of Index numbers, Idea of Consumer price Index number. |
| | | CLO-03 | On completion of this course, students are expected to have an understanding of idea of time series analysis, different components of time series, measuring trend by various methods. |
| 3 | Basic Probability Theory<br>ST-ID-3213 | CLO-01 | On completion of this course, students are expected to have a clear understanding of basic probability theory, random experiment, algebra of events, classical, statistical, and axiomatic definitions of Probability, theorems and laws of probability |
| | | CLO-02 | On completion of this course, students are expected to have a clear understanding of random variables, their p.m.f, p.d.f., expectations and variance |
| | | CLO-03 | On completion of this course, students are expected to have a clear understanding of important discrete and continuous probability distributions. |

## MAPPING OF COURSE LEARNING OUTCOME (CLO) AND PROGRAMME OUTCOME (PO)

| Course Code | CLO | Programme Outcome (PO) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SPO-1 | SPO-2 | SPO-3 | SPO-4 | SPO-5 | SPO-6 | SPO-7 | SPO-8 | SPO-9 | SPO-10 | SPO-11 |
| ST-ID-1113 | CLO - 1 | 3 | | | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 3 |
| | CLO - 2 | 3 | 2 | | 1 | 1 | 3 | 1 | 1 | | 2 | 3 |
| | CLO - 3 | 3 | 3 | | 2 | 1 | 3 | 1 | 1 | | 2 | 3 |
| ST-ID-2113 | CLO - 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 2 | 3 |
| | CLO - 2 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | | 3 | 3 |
| | CLO - 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 1 | | 3 | 3 |
| ST-ID-3213 | CLO - 1 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 3 |
| | CLO - 2 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | | 2 | 3 |
| | CLO - 3 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 1 | | 2 | 3 |

## MAPPING OF COURSE LEARNING OUTCOME (CLO) AND PROGRAMME SPECIFIC OUTCOME (PSO)

| Courses | CLO | Programme Specific Outcome (PSO) | | | |
|---|---|---|---|---|---|
| | | PSO–1 | PSO-2 | PSO-3 | PSO-4 |
| ST-ID-1113 | CLO-1 | 3 | 1 | 1 | 1 |
| | CLO - 2 | 3 | 2 | 2 | 2 |
| | CLO - 3 | 3 | 1 | 2 | 1 |
| ST-ID-2113 | CLO-1 | 3 | 2 | 2 | 2 |
| | CLO - 2 | 3 | 2 | 2 | 1 |
| | CLO - 3 | 3 | 2 | 2 | 1 |
| ST-ID-3213 | CLO-1 | 3 | 2 | 3 | 2 |
| | CLO - 2 | 3 | 3 | 2 | 1 |
| | CLO - 3 | 3 | 2 | 3 | 2 |

**COURSE NAME: Basic Statistics**

**COURSE CODE: ST – ID – 1113**

**TOTAL CREDITS: 3 (Theory: 3)**

**THEORY**

**Total Lectures - 45**

**Course Objective**:

*The objectives of the course are:*

- *To summarize the mass of data, to extract salient features from it and interpretation of results.*
- *To understand the concept of relationship between two variables.*

**Course Learning Outcome:**

*After completing this course, the students should have developed a clear understanding of:*

**CLO – 01:** *Concepts of statistical population and sample, variables*

**CLO – 02:** *Diagrammatic and graphical presentation of data.*

**CLO – 03:** *Measures of central tendency, Dispersion and bivariate data*

**Unit 1: Statistical Data and presentation: (Lectures: 18)**

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Statistical Data: Primary and secondary data, raw data and grouped data, time series and cross sectional data, sample and census data, quantitative and qualitative data, tabular and graphical presentation, constants and variables. Indian Knowledge System (IKS): Idea of IKS, Use of Statistics in Ancient India.

**Unit 2: Descriptive Statistics (Lectures: 15)**

Measures of Central Tendency, partition values. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation.

**Unit 3: Bivariate data (Lectures: 12)**

Idea of Bivariate distribution, scatter diagram, simple correlation and regression.

**RECOMMENDED BOOKS:**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata.
2. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics, 11th Edition. Sultan Chand and Sons, New Delhi.
3. Medhi, J. (2006). Statistical Methods: An Introductory Text. New age international publishers

**COURSE NAME: Applied Statistics**

**COURSE CODE: ST – ID – 2113**

**TOTAL CREDITS: 3 (Theory: 3)**

**THEORY**

**Total Lectures - 45**

**Course Objective**:

*The objectives of the course are to familiarize the students with the:*

- *Concept of sampling theory, Idea of sample survey.*
- *Concept of Index numbers, its uses and limitations.*
- *Idea of time series analysis, Methods in obtaining a Time series.*

**Course Learning Outcome:**

*On completion of this course, students are expected to have an understanding of:*

**CLO – 01**: *Population and sample, A few basic methods of Sampling.*

**CLO – 02**: *Definition and constructions of Index numbers, Idea of Consumer price Index number.*

**CLO – 03**: *Idea of Time series Analysis, Different components of Time Series, Measuring trend by various methods.*

**Unit 1: Idea of Sampling: (Lectures: 15)**

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors, Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, Idea of Stratified and Systematic sampling.

**Unit 2: Index Numbers: (Lectures: 15)**

Index numbers: Definition, Construction of index numbers of prices and quantities, different types of index numbers, tests of Index numbers, consumer price index number, uses and limitations of index numbers.

**Unit 3: Time series analysis: (Lectures: 15)**

Introduction to Time Series Analysis, Components of time series- Secular trend, seasonal variation, cyclical variation and irregular fluctuations with examples, Additive and multiplicative model with their merits and demerits, Measurement of trend by method of free-hand curve, method of semi-averages and Idea of Moving average method.

**RECOMMENDED BOOKS:**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II. The World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals of Applied Statistics, Sultan Chand & Sons
3. Gupta O.P., Chaudhary S.S. Applied Statistics: Kedar Nath Ram Nath

**COURSE NAME: Basic Probability Theory**

**COURSE CODE: ST – ID – 3213**

**TOTAL CREDITS: 3 (Theory: 3)**

**THEORY**

**Total Lectures - 45**

**Course Objective:**

*To familiarize the students with the:*

- *Concept of Probability theory.*
- *Concept of random variables, Mathematical expectation, p.m.f and p.d.f*
- *Different standard probability distributions for both discrete and continuous random variables*

**Course Learning Outcome:**

*On completion of this course, students are expected to have a clear understanding of:*

**CLO – 01:** *Basic probability theory, random experiment, algebra of events, classical, statistical, and axiomatic definitions of Probability, theorems and laws of probability*

**CLO – 02:** *Random variables, their p.mf, p.d.f , expectations and variance*

**CLO – 03:** *Important Discrete and continuous probability distributions.*

**Unit 1: Probability: (Lectures: 10)**

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability.

**Unit 2: Random Variables and Mathematical Expectation: (Lectures: 10)**

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. Illustrations of random variables and its properties. Expectation, variance.

**Unit 3: Standard Probability Distributions: (Lectures 10)**

Idea of standard probability distributions: Bernoulli, Binomial, Poisson, Normal.

**RECOMMENDED BOOKS:**


1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I, 8th Edn. The World Press, Kolkata
2. Gupta S.C. and Kapoor V.K. (2002): Fundamental of Mathematical Statistics, 11$^{th}$ Edn. Sultan Chand and Sons, New Delhi.
3. Agarwal, B. (2007c). Programmed Statistics (Question-Answers). New Age International.
4. Mood, A. M., & Graybill, F. A. (1911). An Introduction to the Theory of Statistics. Nature, 87(2185), 345.


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