PONDICHERRY UNIVERSITY

DEPARTMENT OF STATISTICS

SYLLABUS FOR B.Sc. STATISTICS (Honours)

(NEP 2020 Pattern)

Effective from the Academic Year 2023-2024

NEP –B.Sc. Statistics – Course Structure

Department of Statistics, Pondicherry University
Curriculum for the B.Sc. Statistics (Honours/Honours by research)
(Under the National Education Policy 2020)

National Education Policy 2020

National Education Policy (NEP) 2020 endeavours to provide quality education to students at all levels including those enrolled for higher education (Level 5 and above). Its main aim is to develop individuals who are thoughtful, well-rounded and creative by imparting them holistic and multidisciplinary education. More importantly, NEP 2020 offers students the freedom to shape their studies. Taking into consideration the main recommendations of NEP 2020, University Grants Commission (UGC) has developed a new 'Curriculum and Credit Framework for Undergraduate Programmes' (CCFUP) by revising the existing Choice Based Credit System (CBCS). This framework was published in December 2022 integrating the ethos of NEP 2020 to allow for multiple entry and exit, flexible degree options thereby facilitating students to pursue their career path by choosing the subject/field of their interest.

The guidelines for Undergraduate programme in Statistics to be offered by Pondicherry University have been framed in line with NEP regulations framed by Pondicherry University for undergraduate programmes based on CCFUP and can be accessed by following the link: **Curriculum and Credit Framework for Undergraduate Programmes.** CCFUP outlines an indicative framework for Higher Education Institutions (HEIs) to develop undergraduate programmes but also provides necessary flexibility to design programmes to suite the needs of students and HEIs. Hence, this document has been prepared by the Department of Statistics, Pondicherry University for undergraduate programmes in Statistics to be offered by Pondicherry University adhering to minimum requirements outlined in CCFUP with suitable modifications as necessary and approved by the competent Board of Studies.

Definitions

a. Semester: A semester comprises of approximately 90 working days and an academic year is divided into two semesters.

b. Summer Term: A summer term is for four to six weeks during summer vacation. Internship/apprenticeship/work-based vocational education and training can be carried out during the summer term, especially by students who wish to exit after two semesters or four semesters of study.

c. Credit: A credit is a unit by which the coursework is measured. It determines the number of hours of instruction required per week over the duration of a semester which will be approximately minimum 15 weeks. Hence, a 4 credit lecture course will have 4 hours of instruction per week.

Type of Course and Number of Credits

1. **Major Discipline Courses:** Major discipline is the discipline or subject of main focus and the degree will be awarded in that discipline. For students enrolled in Department of Statistics, courses related to Statistics marked as 'Discipline-Specific Course – Core' mentioned in Table 3 are considered as Major Discipline Courses. All Major Discipline Courses will be for 4 credits.

   Change of Major: Students can opt for a change of major within the broad discipline (Natural and Physical Sciences, Mathematical, Statistics, and Computational Sciences, Library, Information and Media Sciences, Commerce and Management, and Humanities and Social Sciences) at the end of the first year. additional 10% seats over and above the sanctioned strength to accommodate the request for a change of major. Any unfilled

or vacant seats may be filled with those seeking a change of Major. Preference will be given to those who have got highest CGPA with no arrears in the first year.

2. **Minor Discipline Courses:** These courses help a student to gain a broader understanding beyond the major discipline. All Discipline-Specific Minor Courses will be for 4 credits. Students who take a sufficient number of courses in a discipline or an interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline or in the chosen interdisciplinary area of study. 50% of the total credits from minors must be secured in the relevant subject/discipline (Statistics) and another 50% of the total credits from a minor can be earned from any discipline as per students' choice. Student can declare the choice of the minor and vocational stream at the end of the second semester, after exploring various courses.

3. **Other Courses:** All courses under the Interdisciplinary / Multidisciplinary, Ability Enhancement (language), and Skill Enhancement categories will be of 3-credits.

   Multidisciplinary Courses: All UG students are required to undergo 3 introductory-level courses relating to any of the broad disciplines relating to Natural and Physical Sciences / Mathematics, Statistics, and Computer Applications / Library, Information, and Media Sciences / Commerce and Management / Humanities and Social Sciences. These courses are intended to broaden the intellectual experience and form part of liberal arts and science education. Students are not allowed to choose or repeat courses already undergone at the higher secondary level (12th class) in the proposed major and minor stream under this category.

   Ability Enhancement Courses (Language): Students are required to achieve competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills.

   Vocational Education and Training**:** Vocational Education and Training will form an integral part of the undergraduate programme to impart skills along with theory and practical. A minimum of 12 credits will be allotted to the 'Minor' stream relating to Vocational Education and Training and these can be related to the major or minor discipline or choice of the student. These courses will be useful to find a job for those students who exit before completing the programme.

4. **Common Value-Added Courses:** Courses under Value Added, Summer Internship / Apprenticeship / Community outreach activities, etc., will be of 2-credits.

   Value-Added Courses: These courses will be offered at the university level commonly for all students registered for various undergraduate programmes. These courses include Understanding India, Environmental Science, Health & Well-being / Yoga, Digital & Technological Solutions or any other course offered by the university from time to time. The credit for each of these courses will be in accordance with the university guidelines. One or two courses of these will be offered in each semester upto 2nd semester.

   Summer Internship: All students will also undergo internships / Apprenticeships in a firm, industry, or organization or Training in labs with faculty and researchers in their own or other HEIs/research institutions / industry / government bodies during the summer term. Students who wish to exit after the first two semesters will undergo a 4-credit work-based learning/internship during the summer term in order to get a UG Certificate.

5. **Research Project / Dissertation:** Students choosing a 4-Year Bachelor's degree (Honours with Research) are required to take up research projects under the guidance of a faculty member. The students are expected to complete the Research Project in the eighth semester. The research outcomes of their project work may be published in peer-reviewed journals or may be presented in conferences /seminars or may be patented.

Intake for B.Sc. (Honours) Statistics

Department of Statistics, Pondicherry University– 30 students

Eligibility

Senior Secondary School Leaving Certificate or Higher Secondary (12th Grade) Certificate passed with a minimum of 50% of marks with Statistics or Mathematics as subjects of study or equivalent stage of education corresponding to Level-4 from board recognised by UGC or Government of India.

Undergraduate Programmes

a. **Undergraduate Certificate in Statistics:** Students who opt to exit after completion of the first year and have secured 42 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

b. **Undergraduate Diploma in Statistics:** Students who opt to exit after completion of the second year and have secured 84 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

c. **3-year Bachelor of Arts (B.Sc.) Statistics**: Students who wish to undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 124 credits and satisfying the minimum credit requirement as given in Table 2.

d. **4-year B.Sc. (Honours) Statistics:** A four-year UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 164 credits and have satisfied the credit requirements as given Table 2.

e. **4-year B.Sc. (Honours with Research) Statistics**: Students who secure a CGPA of 7.5 and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

Infrastructure: The Departments offering a 4-year UG Degree (Honours with Research) must have the required infrastructure such as the library, access to journals, computer lab and software, laboratory facilities to carry out experimental research work and additional permanent faculty members as approved by the Board of Studies.

Duration of the Programme

a. The duration of the UG programme is 4 years or 8 semesters. Students who desire to undergo a 3-year UG Programme will be allowed to exit after completion of the 3rd year. If a student wants to leave after the completion of the first or second year, the student will be given a UG Certificate or UG Diploma, respectively, provided they secure the prescribed number of credits (as given in Table 2). Students who exit with a UG certificate or UG diploma are permitted to re-enter within three years and complete the degree programme.

b. Students may be permitted to take a break from the study during the period of study but the total duration for completing the programme shall not exceed 7 years.

Minimum Credit Requirements

The course-wise breakup of minimum credit requirements for B.Sc. Statistics, B.Sc. (Honours) Statistics and B.Sc. (Honours with Research) Statistics programme as provided in UGC Curriculum and credit framework.

Table 1: Minimum Credit Requirements to Award Degree under Each Category prescribed by PU NEP regulation 2023 -24

S. No.	Broad Category of Course	Minimum Credit Requirement	
		3-year B.Sc. Statistics	4-year B.Sc. (Honours) Statistics
1	Major (Core)	60	80
2	Minor Stream	24	32
3	Multidisciplinary/Inter-disciplinary	09	09
4	Ability Enhancement Courses (AEC)[#]	12	12
5	Skill Enhancement Courses (SEC)	09	09
6	Value Added Courses common for all UG	08	08
7	Summer Internship	04 (included in Major courses of 60 credits)	04 (included in Major courses of 80 credits)
8	Community engagement and service	2 credits (1 course)	2 credits (1 course)
9	Research Project / Dissertation[*]	-	12
	Total	**124**	**164**

Note: *Compulsory for only those students who opt for B.Sc. (Honours with Research) Statistics programme. Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research project / Dissertation.

Undergraduate Degree Programmes with Flexible Degree Options

a. **UG Degree Programmes with Single Major:** A student has to secure a minimum of 50% credits from the major discipline for the 3-year/4-year UG degree to be awarded a single major.

b. **UG Degree Programmes with Single Major and Minor:** A student has to secure at least 50% of the credits earmarked for 'Minor Stream' from a particular major discipline apart from the discipline that he/she has selected as major discipline to be able to obtain a major with a minor in that particular discipline. Accordingly, for 3-year / 4-year UG Degree programme, a student must earn at least 12 credits and 16 credits respectively in a particular major discipline to be eligible to obtain a minor in that subject. For example, if a student pursuing an Statistics major obtains a minimum of 12 credits from a bunch of courses in Statistics, then the student will be awarded B.A. degree in Statistics with a Minor in Statistics.

Evaluation and Award of Grades

Weightage of marks: The weightage of marks between continuous Internal Assessment and End- Semester Examination shall be 40 and 60, respectively.

Passing Minimum: A student is declared to have passed a given course only when he/she secures a minimum of 40 % marks in the end-Semester Examination and an aggregate of 50 % marks (both Internal and End-Semester

Examination put together). There is no minimum passing marks for the internal assessment component. This is subject to revision as per university regulation.

Internal Assessment: Internal Assessment Component of 40 marks consists of the following:

1. Two Class Tests (15+15)		:	30 marks
2. Assignment/Seminar		:	10 marks
	Total	:	**40 marks**

However internal assessment for skill based and vocational courses can have components like practicum/ skill based test/ assessment of field report etc.

End-Semester examination Question Paper Pattern for major/ minor: The question paper pattern for each of the subjects for the End-Semester written examination shall be as given below:

Section A	:	FOUR (04) questions to be answered out of SIX (06) questions	**4 x 6 marks = 24 marks**
Section B	:	THREE (03) questions to be answered out of FIVE (05) questions	**3 x 12 marks = 36 marks**
		Total	**60 marks**

Both sections should be representative of the entire syllabus hence, must contain at least one question from each module.

However, depending on the course contents and the orientation of the teaching, the above question paper pattern can be modified for individual courses subject to the approval from the departmental programme committee. In case of skill based and vocational courses, end semester examination can have components like practicum/ skill based test/ assessment of field report etc. with composition of marks as approved by the departmental programme committee.

For Summer Internship at the end of first or second year, the evaluation pattern will be as follows: Internship report: 60 marks and Viva-Voce: 40 marks

Grading: Grading of the marks obtained by the students shall be made as per the norms as prescribed by the University which is subject to change from time to time.

Attendance: Each student shall obtain a minimum of 70 per cent (70%) attendance to be eligible for appearing for the End-Semester Examination details of which is prescribed by the academic regulations of the University. Concessions on minimum attendance, as per the university guidelines, if any, will be applicable.

Table 2: Curriculum Structure and Credit requirements for UG Programme in Statistics in Pondicherry University

Course-wise breakup of minimum credit requirements for B.Sc. Statistics, B.Sc. (Honours) Statistics and B.Sc. (Honours with Research) Statistics programme to be offered by the Department of Statistics, Pondicherry University.

Semester – I

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 111	Major Discipline 1	4	Descriptive Statistics
STAT 112	Minor Discipline 1	4	Mathematics for Statistics - I
ENG 1	Ability Enhancement Courses (AEC)	3	English – I (offered by English Dept.)
STAT 113	Multi-disciplinary Courses (MD) (*Students have to select a course from a Bouquet of courses*)	3	Introduction to Statistics (*for other department students*)
VAC 1	Value added Course (VAC)	2	Understanding India
VAC 2	Value added Course (VAC)	2	Environmental Science
STAT 114	Skill Enhancement Course(SEC 1)	3	Data Analysis with Excel – I
	Semester Credits	**21**	

Semester – II

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 121	Major Discipline 2	4	Probability Theory
STAT 122	Minor Discipline 2	4	Mathematics for Statistics - II
MIL 1	Ability Enhancement Courses (AEC)	3	Language – I (Offered by Languages Dept.)
STAT 123	Multi-disciplinary Courses (MD) (Students have to select a course from a Bouquet of courses)	3	Introduction to Probability Theory (for other departments)
VAC 3	Value added Course (VAC)	2	Health and Well Being/YOGA/ Fitness
VAC 4	Value added Course (VAC)	2	Digital Technology
STAT 124	Skill Enhancement Course (SEC 2)	3	Data Analysis with Excel – II
	Semester Credits	**21**	

Students who opt to exit after completion of first year will be awarded **UG Certificate in Statistics** provided they have earned a minimum of **42 credits** and in addition, they complete work based vocational course/internship of **4 credits** during the summer vacation of the first year.

Semester – III

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 231	Major Discipline 3	4	Distribution Theory
STAT 232	Major Discipline 4	4	Applied Statistics
STAT 233	Minor Discipline 3	4	Real Analysis
STAT 234	Multi-disciplinary Courses (MD) (Students have to select a course from a Bouquet of courses)	3	Statistical Methods
ENG 2	Ability Enhancement Courses (AEC)	3	English – II (offered by English Dept.)
STAT 235	Skill Enhancement Course (SEC)	3	Exploratory Data Analysis Using R
	Semester Credits	**21**	

Semester – IV

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 241	Major Discipline 5	4	Sampling Theory
STAT 242	Major Discipline 6	4	Estimation Theory
STAT 243	Major Discipline 7	4	Official Statistics
STAT 244	Minor Discipline 4	4	Numerical Methods
MIL 2	Ability Enhancement Courses (AEC)	3	Language – I (Offered by Languages Dept.)
VAC 5	Value added Course (VAC)	2	Community Engagement and Service
	Semester Credits	**21**	

Students who opt to exit after completion of second year will be awarded **UG Diploma in Statistics** provided they have earned a minimum of **84 credits** and in addition, they complete work based vocational course/internship of **4 credits** during the summer vacation of the second year.

Semester – V

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 351	Major Discipline 8	4	Testing of Statistical Hypotheses
STAT 352	Major Discipline 9	4	Demography
STAT 353	Major Discipline 10	4	Statistics using R
STAT 354	Minor Discipline 5	4	Operations Research
STAT 355	Major Discipline 11 (Internship)	4	Internship
	Semester Credits	**20**	

Semester – VI

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 361	Major Discipline 12	4	Principles of Experimental Design
STAT 362	Major Discipline 13	4	Actuarial Statistics
STAT 363	Major Discipline 14	4	Introductory Statistics using Python
STAT 364	Major Discipline 15	4	Statistical Quality Control
STAT 365	Minor Discipline 6	4	Basic Econometrics
	Semester Credits	**20**	

Students who opt to exit they will be awarded with a **B.Sc. Statistics** after successful completion of three years, provided they have earned a minimum of **124 credits.**

Semester – VII

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 471	Major Discipline 16	4	Advanced Probability Theory
STAT 472	Major Discipline 17	4	Advanced Distribution Theory
STAT473	Major Discipline 18	4	Statistical Inference I
STAT 474	Minor Discipline 7	4	Advanced Sampling Theory
STAT 475	Minor Discipline 8	4	Regression Analysis
	Semester Credits	**20**	

Semester – VIII - B.Sc. Statistics (Honours by course work)

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 481	Major Discipline 19	4	Statistical Inference II
STAT 482	Major Discipline 20	4	Multivariate Statistical Analysis
STAT 483	Major Discipline 21	4	Design of Experiments
STAT 484	Major Discipline 22	4	Stochastic Processes
STAT 485	Major Discipline 23	4	Reliability Theory
	Semester Credits	**20**	

A student successfully who complete a four-year degree programme, earning a minimum of **164 credits** will be awarded a degree in **B.Sc. Statistics (Honours)**

Semester – VIII - B.Sc. Statistics (Honours by research)

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 481	Major Discipline 19	4	Statistical Inference II
STAT 482	Major Discipline 20	4	Multivariate Statistical Analysis
STAT 483			Design of Experiments
STAT 484			Stochastic Processes
STAT 485			Reliability Theory
STAT 486			Research Methodology
STAT 487	Major Discipline 21	12	Research Project/ Dissertation
	Semester Credits	**20**	

Students who secure a minimum of **7.5 CGPA** in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University. The research project/dissertation

will be in the major discipline. The students who secure a minimum of **164 credits**, including **12 credits** from a research project/dissertation, will be awarded **B.Sc. Statistics (Honours with research).**

STUDENTS WHO COMPLETE UG DEGREE IN THE MAJOR DISCIPLINE WITH HONOURS CAN OPT FOR ONE YEAR MASTERS DEGREE WITH RESEARCH

(FOR THOSE WHO NOT OPTED FOR UG DEGREE BY RESEARCH)

Semester – IX - M.Sc. Statistics (with research)

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 591	Major Discipline 19	4	Multivariate Statistical Analysis
STAT 592	Major Discipline 20	4	Research Methodology
STAT 593	Major Discipline 21#	4	Probability Distribution and Inference
STAT 594			Stochastic Modelling and Optimization Methods
STAT 595			Life Testing and Bayesian Inference
STAT 596			Biostatistics and Mixture Models
	Semester Credits	**12**	

 # Student can opt for one paper from the listed courses as specialization

Semester – X - M.Sc. Statistics (with research)

Course Code	*Type of Course*	*Credits*	*Title of the Course*
STAT 597	Research Project/ Dissertation	12	Project Work and Comprehensive Viva-Voce
	Semester Credits	**12**	

FIRST YEAR – SEMESTER I

Course Code	STAT 111	DESCRIPTIVE STATISTICS	L	T	P	Credits
Core	MAJOR 1	Semester I	4	1	-	4
Pre-requisite		Knowledge of Mathematics	Syllabus Version		2023-24	

Course Objectives

To learn the basic concepts of Statistics such as types of data and graphical approach to data.

Expected Course Outcomes

On the successful completion of the course, student will be able to classify and analyze the data

Unit:1

Definition of statistics: Scope and limitations of statistics – Types of data – Nominal, Ordinal, Ratio, Interval scale data - Primary and Secondary data – Data presentation tools – One dimensional, two dimensional data presentation – line diagram – Box plots – stem and Leaf plots – Scatter plots. Measures of Central Tendency: Arithmetic Mean, Median, Mode, Geometric mean and Harmonic mean.

Unit:2

Measures of Dispersion: Range, Quartile Deviation, Mean Deviation and Standard Deviation, Coefficient of Variation. Central and Non-Central moments and their interrelationship. Sheppard's correction for moments. Skewness and kurtosis.

Unit:3

Curve fitting: Bi-variate data, Principle of least squares, fitting of straight line, Second-degree parabola, power curve and exponential curves.

Correlation: Meaning, Types of Correlation, Measures of Correlation: Scatter diagram, Karl Pearson's Coefficient of Correlation, Rank Correlation Coefficient (with and without ties), Bi-variate frequency distribution, correlation coefficient for bi-variate data and simple problems. Concept of multiple and partial correlation coefficients (three variables only) and properties.

Unit:4

Attributes: Notations, Class, Order of class frequencies, Ultimate class frequencies, Consistency of data, Conditions for consistency of data for 2 and 3 attributes only, Independence of attributes, Association of attributes and its measures, Relationship between association and colligation of attributes, Contingency table: Square contingency, Mean square contingency, Coefficient of mean square contingency, Tschuprow's coefficient of contingency.

Total Lecture Hours | **60 Hours**

Books for Study

1. Hooda.R.P. (2003), Statistics for Business and Economics , 3/e, Mac Millan
2. Medhi.J. (2006), Statistical Methods: An Introductory Text , Wiley Eastern Ltd.
3. Gupta.S.C. and Kapoor.V.K. (2014), Fundamentals of Mathematical Statistics, 12/e, Sultan Chand and sons.
4. Agarwal.B.L (2013), Basic Statistics, 6/e, New Age International Publishers.

Reference Books

1. Anderson.R, Sweeney.J and Williams.A (2019): Statistics for Business and Economics, 13/e, Cengage Publishers
2. Sheldon M.Ross (2005), Introductory Statistics , 2/e, Elsevier Publications.
3. Murray R. Spiegel and Larry J. Stephens (2005), Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

Course Code	STAT 112	MATHEMATICS FOR STATISTICS – I	L	T	P	Credits
Core	MINOR 1	Semester II	4	1	-	4
Pre-requisite		Knowledge in Mathematics (higher secondary level)	Syllabus Version	2023-24		

Course Objectives

1. To understand the derivatives of functions
2. To apply the concept of derivative

Expected Course Outcomes

To understand geometric meaning of derivatives
To learn the concept of successive differentiation
To understand some basic functions and its partial differentiation

Unit:1

Derivative of a function- Differentiation rules- Rate of change- Derivatives of trigonometric functions- Chain Rule- Implicit differentiation rational exponents Inverse functions and their derivatives- Hyperbolic function.

Unit:2

Application of Derivatives- Increasing decreasing functions - Maxima minima-Error –Approximation- Optimization-Newton method- Mean value theorems- Taylor theorem- Maclaurins theorem.

Unit:3

Asymptotes- Test of concavity& convexity point of inflexion- Multiple point training curves in Cartesian & Polar co-ordinates.

Unit:4

Successive differentiation- Leibnitz rule- Problems and examples - Exponent function a^x, log—functions- Theorems on exponent & Log functions- Partial differentiation- Chain rule- Eulers theorem.

Total Lecture Hours **60 Hours**

Books for Study

1. George B.Thomas, Maurice D.Weir and Joel Hass, Thomas' Calculus 12th Edition, Pearson Education, 2015.

Reference Books

1. Richard Courant and Fritz John, Introduction to Calculus and Analysis, Vol.I, Springer 1999.
2. Serge Lang A First course in Calculus 5th edition, Springer, 1999.

Course Code	STAT 113	INTRODUCTION TO STATISTICS	L	T	P	Credits
Core	Multi-Disciplinary (MD 1)	Semester I	3	1	-	3
Pre-requisite		Knowledge in Mathematics (at higher secondary level)	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:
1. To learn the about different data types, diagrammatic and graphical representation of the data
2. To learn about measure of central tendency and measures of dispersion
3. To learn about correlation and regression

Expected Course Outcomes

On the successful completion of the course, student will have knowledge on theoretical as well as practical approach on
1. various techniques used in summarization, presentation and analysis of different types of Statistical data
2. Simple and rank correlation, Partial and Multiple correlation coefficients.
3. Fitting of linear and quadratic regressions using principle of least squares, Association Analysis

Unit:1

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Scales of measurement -nominal, ordinal, interval and ratio. Variables and attributes, Diagrammatical Representation of Data, Summarization of Data: Frequency Distribution and Graphical Presentation.

Unit:2

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, measures of skewness and kurtosis.

Unit:3

Bivariate data: Definition, scatter diagram, simple correlation, rank correlation. Trivariate Data: Partial and Multiple correlation coefficients.

Unit:4

Fitting of linear and quadratic regression using principle of least squares. Theory of attributes and consistency of data, independence and association of attributes, measures of association and contingency for 2 x 2 and r x s contingency tables.

Total Lecture Hours | **60 Hours**

Books for Study

1	Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, , World Press, Kolkata.
2	Mood, A.M. Graybill, F.A. and Boes, D.C. (2017). Introduction to the Theory of Statistics, 3rd Edn., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.
3	Rohatgi, V.K. and Saleh, A.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Course Code	STAT 114	DATA ANALYSIS USING EXCEL-I	L	T	P	Credits
Core	Skill Enhancement (SEC 1)	Semester I	3	1	-	3
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are:

1. To train the students to handle and present the data with various statistical measures in excel
2. To improve the analytical skills of students using built in statistical functions and routines of excel
3. To perform relational and association analysis for the given data.

Expected Course Outcomes:

Students will be able to:

1. Carry out the basic level statistical analysis using the statistical functions in excel
2. Will be able to present the data graphically in a meaningful manner
3. Will be getting acquaintance with many statistical techniques and functions in excel

Unit:1	Introduction to Excel	

File Operations – Open, Save, close – Data operations – Creating forms to enter data – concatenation of text, numbers – Splitting of data into columns – Sort and reverse sort – Grouping and ungrouping of data

Unit:2	Graphical statistics using Excel	

One dimensional, two dimensional data presentation – Histogram, line diagram – Box plots – Scatter plots. Bar charts – stack, subdivided, pie charts, radar graphs

Unit:3	Measures of Central Tendency	

Arithmetic Mean, Median, Mode, Geometric mean and Harmonic mean, Range, Quartile Deviation,

Unit:4	Statistical measures using Excel	

Mean Deviation, Standard Deviation, Coefficient of Variation. Central and Non-Central moments and their interrelationship. Sheppard's correction for moments. Skewness and kurtosis.

Total Lecture Hours	45 Hours

Books for Study:

1	Sarma KVS (2010), Statistics Made Simple: Do it Yourself on PC, PHI, India, 2/e
2	Wayne, W L (2019), Microsoft Excel: Data Analysis & Business Model, PHI

Reference Books:

1	Nelson, S.L and Nelson, E C (2018), Microsoft data analysis for dummies, Wiley
2	Berk, K. N and Carey, P (2000), Data Analysis with Microsoft Excel, S.Chand (G/L) & Company Ltd, 3/e

FIRST YEAR – SEMESTER II

Course Code	STAT 121	PROBABILITY THEORY	L	T	P	Credits
Core	MAJOR 2	Semester II	4	1	-	4
Pre-requisite		Knowledge in Numbers(Real, Integer), Set theory, Bounds, Sequence, Convergence	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. Review the basic concepts of Random experiments, Trials and Events, and Sample Space
2. Study about properties of Probability and obtaining event probability
3. Study Conditional events and probability

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1. Understand the basic concepts of probability theory
2. Study addition and multiplication theorem, moment generating function
3. Learn about various types of Convergence and Central Limit theorem

Unit:1

Introduction to probability theory – Random experiments, Events, Sample space, Operations on events and types of events – Mathematical, Statistical and Axiomatic definitions of Probability – Simple problems.

Unit:2

Addition and Multiplication law of probability - Boole's inequality- Conditional probability – Bayes Theorem - Simple problems - Random variable - Discrete and Continuous – Probability Mass function and Probability Density Function – Bivariate random variables

Unit:3

Expectation – Variance - Moments: Raw and central moments and their relations, Moment Generating Functions and Probability Generating Functions–Simple problems.

Unit:4

Chebychev's inequality - Cauchy – Schwartz inequality – Definition of convergence in probability and distribution - Weak Law of Large numbers (WLLN) - Central Limit theorem for i.i.d case (statement only)

Total Lecture Hours **60 Hours**

Books for Study

1. Hogg, R.V. , Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition
2. Gupta,S.C. and Kapoor, V.K. (2000): Fundamentals of Mathematical Statistics, 10/e, Sultan Chand and sons.

Reference Books

1. Mood, A.M., Graybill, F.A and Boes, D.C.(1974): Introduction to the Theory of Statistics, McGraw Hill.

Course Code	STAT 122	MATHEMATICS FOR STATISTICS -II	L	T	P	Credits
Core	MINOR 2	Semester II	4	1	-	4
Pre-requisite		Knowledge in Mathematics (higher secondary level)	Syllabus Version	2023-24		

Course Objectives

To learn the basic concepts of matrices, Linear Equations**,** partial differentiation, Gamma Integral and Laplace transform

Expected Course Outcomes

On completion of the course, students will be able to apply mathematical techniques for deriving statistical distributions.

Unit:1

Matrices: Elementary, scalar, Hermitian, skew-Hermitian, symmetric, skew-symmetric, Unitary, triangular, equivalent and similar matrices- Transpose and conjugate of a matrix – Rank of a matrix

Unit:2

System of Linear Equations- Consistency-Different types of solutions – Inverse of a Matrix. Characteristics Equation – Eigen values and Vectors –Cayley Hamilton Theorem.

Unit:3

Partial differentiation – Maxima and Minima of functions of two variables- Integration – Properties of Definite Integrals – Reduction formula – Bernoulli's formula - Double Integrals – Evaluation in simple cases only – Use of Jacobian transformation

Unit:4

Definitions of Beta and Gamma Integrals – Recurrence Formula for Gamma Integral Properties of Beta Integral– Application of Beta Gamma Integrals – Relation between Beta and Gamma Integrals. Laplace Transform: Introduction – definition – properties – Laplace transforms ofstandard functions – derivatives and integrals of transforms – transform of derivatives and integrals

Total Lecture Hours **60 Hours**

Books for Study

1. M.K. Venkataraman (1965): Engineering Mathematics, National Publishing Company, Chennai
2. T.K. Manicavachagom Pillay, T. Natarajan, K.S. Gnanapathy, Calculus, Vol I, II & III, S. Viswanathan Printers & Publishers Pvt.Ltd., Chennai
3. T.K. Manicavachagom Pillay, T. Natarajan, K.S. Gnanapathy (1999), Algebra, Volume II, S. Viswanathan Printers & Publishers Pvt.Ltd., Chennai

Reference Books

1. B.S. Grewal (2014): Higher Engineering Mathematics, Khanna Publishers

Course Code	STAT123	INTRODUCTION TO PROBABILITY THEORY	L	T	P	Credits
Core	MD 2	Semester II	3	1	-	3
Pre-requisite		Knowledge in Mathematics (at higher secondary level)	Syllabus Version		2023-24	

Course Objectives:

This course will lay the foundation to probability theory and Statistical modelling of outcomes of real-life random experiments through various Statistical distributions.

Expected Course Outcomes:

The students will get to know about

1. Writing of sample space, events and algebra of events and finding Probability of events.
2. Conditional Probability and applications of Bayes' theorem.
3. Discrete and continuous random variables, probability mass function and probability density function cumulative distribution function.

Unit:1

Probability: Introduction, random experiments, sample space, events – Types of events - Definitions of Probability – classical, statistical and axiomatic - Conditional Probability - Addition and Multiplication theorem of probability - Bayes' theorem – Simple problems.

Unit:2

Random Variables: Discrete and continuous random variables, Probability mass function , Probability density function , Cumulative distribution function their properties. Expectation, variance, moments and moment generating function.

Unit:3

Discrete probability distributions: Binomial, Poisson, Geometric, Negative Binomial, Hyper geometric – properties and applications.

Unit:4

Continuous Probability distributions: Uniform, Normal, Exponential, Beta, Gamma - properties and applications

Total Lecture Hours **45 Hours**

Books for Study

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013). Fundamental of Statistics, Vol I, , World Press, Kolkata.
2. Mood, A.M. Graybill, F.A. and Boes, D.C. (2011). Introduction to the Theory of Statistics, 3rd Edn., (Indian Edition), Tata McGraw-Hill Pub. Co. Ltd.
3. Rohatgi, V.K. and Saleh, A.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Reference Books

1. Goon, A.M., Gupta, M.K. and Das Gupta,B. (2016): Fundamentals of Statistics, Vol. II, World Press, Calcutta.
2. Miller, I. and Miller, M. (2006). John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.

Course Code	STAT124	DATA ANALYSIS USING EXCEL-II	L	T	P	Credits
Core	SEC 2	Semester II	3	1	-	3
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are:

1. To train the students to handle and present the date with various statistical measures in excel
2. To improve the analytical skills of students using built in statistical functions and routines of excel

Expected Course Outcomes:

Students will be able to:

1. Perform basic problems on probability
2. Will be able to generate random numbers and compute basic measures

Unit:1	Basic Probability using Excel	

Addition and Multiplication law of probability - Conditional probability – Bayes Theorem - Simple problems.

Unit:2	Random Number Generation using Excel	

Generation of random numbers for discrete and continuous random variables - Expectation – Variance - Moments: Raw and central moments

Unit:3	Relational Analysis using Excel	

Curve fitting: Bi-variate data, fitting of straight line, Second-degree parabola, power curve and exponential curves. Correlation: Meaning, Types of Correlation, Measures of Correlation: Scatter diagram, Goodness of fit and association of attributes.

Unit:4	Tabulation Analysis using Excel	

Cross tabulation, summaries and basic calculations using Pivot Tables, Pivot charts – Matrix Operations – Addition, multiplication, subtraction, inverse and transpose

Total Lecture Hours	45 Hours

Books for Study:

1	Sarma KVS (2010), Statistics Made Simple: Do it Yourself on PC, PHI, India, 2/e
2	Wayne, W L (2019), Microsoft Excel: Data Analysis & Business Model, PHI

Reference Books:

1	Nelson, S.L and Nelson, E C (2018), Microsoft data analysis for dummies, Wiley
2	Berk, K. N and Carey, P (2000), Data Analysis with Microsoft Excel, S.Chand (G/L) & Company Ltd, 3/e

SECOND YEAR – SEMESTER III

Course Code	STAT231	DISTRIBUTION THEORY	L	T	P	Credits
Core	MAJOR 3	Semester III	4	1	-	4
Pre-requisite		Basic Probability Theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are:

1. To learn the concepts of discrete and continuous distributions.
2. To learn about sampling distributions like Chi-Square, Student's t (Fisher's t) and Snedecor's F distributions and their applications.

Expected Course Outcomes

On the successful completion of the course, student will acquire:

1. Knowledge of important discrete distributions such as Binomial, Poisson, Geometric, Negative Binomial and Hyper-geometric and their interrelations (if any)
2. To apply standard discrete probability distribution to different situations.
3. Knowledge of important continuous distributions such as Uniform, Normal, Exponential, Beta and Gamma and relations with some other distributions and their applications.

Unit:1

Discrete Distributions: Bernoulli, Binomial - Poisson - Geometric – Uniform distributions - Definition, properties, characterizations and simple problems.

Unit:2

Negative Binomial - Multinomial – Hypergeometric distributions - Definition, properties, characterizations and simple problems.

Unit:3

Continuous Distributions: Uniform - Exponential – Normal - Cauchy - Gamma - Beta distributions (First and Second kind) - Definition, properties, characterizations and simple problems.

Unit:4

Definition of Sampling distributions and standard error - Sampling distributions: central t, central F and central chi-square distributions – derivation of pdf and their characteristics.

Total Lecture Hours **60 Hours**

Books for Study:

1. Hogg, R.V. , Mc Kean J W and Craig, A.T.(2021): Introduction to Mathematical Statistics, 8/e Pearson Edition.
2. Mood, A.M., Graybill, F.A and Boes, D.C. (2017): Introduction to the Theory of Statistics, 3/e, McGraw Hill.
3. Rohatgi, V.K. and Saleh, A.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.

Reference Books:

1. Goon, A.M., Gupta, M.K. and Das Gupta,B. (2016): Fundamentals of Statistics, Vol. II, World Press, Calcutta.
2. Irwin Miller and Marlyees Miller (2013): John E Freund's Mathematical Statistics, 8/e, PHI.

Course Code	STAT232	APPLIED STATISTICS	L	T	P	Credits
Core	MAJOR 4	Semester III	4	1	-	4
Pre-requisite		Basic Statistics	Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are:

1. To learn the concepts of time series, evaluation, measurement of trend and seasonal variations by various methods.
2. To learn about Index numbers.
3. To learn about the various measures of mortality and fertility.

Expected Course Outcomes:

On the successful completion of the course, student will acquire:

Students will gain the knowledge about Analysis of time series, index numbers and vital statistics.

Unit:1

Index Numbers: Construction of index numbers; fixed and chain base index numbers; weighted index numbers; standard index numbers; Tests for index numbers; cost of living index number and its construction.

Unit:2

Time Series Analysis: Components of a time series – methods for measurement of trend and Seasonal variations – moving average, ratio to trend, ratio to moving average, exponential smoothing

Unit:3

Vital Statistics: Methods of obtaining Vital Statistics, Methods of measuring population - Measures of mortality – Crude and specific rates, standardized rates, Infant mortality rate - Complete life table - its construction and uses. Abridged life tables.

Unit:4

Measures of Fertility: Crude Birth Rate (CBR), Age Specific Fertility Rate (ASFR), General Fertility Rate (GFR) and Total Fertility Rate (TFR) - Crude, Specific and standardized rates - Measures of migration, Population growth rates - Gross Reproduction Rate and Net Reproduction Rate.

Total Lecture Hours **60 Hours**

Books for Study

1. Kapoor.V.K. and Gupta.S. (2014): Fundamentals of Applied Statistics, Sultan Chand and Sons.
2. Parimal Mukhopadhyay (2022): Applied Statistics, Books and Allied (P) Ltd, Kolkata.
3. B L Agarwal (2013): Basic Statistics, New Age International Publishers.

Reference Books

1. Goon.A.M., Gupta.M.K. and Das Gupta .B (2016) : Fundamental of Statistics , Vol. II, World Press , Calcutta.
2. Bogue.D.J. (1969) : Principles of Demography , John Wiley.
3. Misra.B.D. (1982): An Introduction to the Study of Population, South Asian Publishing.

Course Code	STAT 233	REAL ANALYSIS	L	T	P	Credits
Core	MINOR 3	Semester III	4	1	-	4
Pre-requisite		Knowledge in Mathematics (higher secondary level)	Syllabus Version	2023-24		

Course Objectives

To learn Real number system, convergence and divergence, functions, algebra of functions and Riemann integration.

Expected Course Outcomes

On the successful completion of the course, student will be able to:

Students will learn the mathematical concepts pertaining to sequences and series, functions, its derivative and integration.

Unit:1

Real valued functions – Equivalence – Countability – Real numbers – Least upper bound – Greatest lower bound. Sequence of real numbers: Limit of a sequence – Convergent sequences, Divergent sequences - Bounded sequences - Monotone sequences – Cauchy's first and second theorem on limits – Cauchy's general principle of convergence

Unit:2

Series of real numbers : Convergence and divergence - series with non-negative terms – comparison test – p-test, D'Alembert's ratio test, Cauchy's Root test – Alternating series – Conditional convergence and absolute convergence – Leibnitz test (proof of the test can be omitted, only problems).

Unit:3

Functions : Limit of real valued function in one variable, continuity – types of discontinuities – algebra of continuous functions – Extreme value theorem – Intermediate value theorem – Uniformly Continuous functions – Increasing and Decreasing functions – Differentiability – Darboux'sTheorm – Rolle's Theorem – Mean value theorem for derivatives – Taylor's Series expansion

Unit:4

Riemann Integration – Definition and existence of the integral – refinement of partitions – Darboux's theorem – Conditions of Integrability – Integrability of sum and modulus of integrable functions – Integration and Differentiation – Fundamental Theorem of Calculus

Total Lecture Hours **60 Hours**

Books for Study

1. Malik S.C. and Savita Arora (2010): Mathematical Analysis, 4/e, New Age International Publishers
2. D. Somasundaram and B. Choudhary (2002) : A first course in Mathematical Analysis, Narosa Publishing house
3. R. R. Goldberg (1970) : Methods of Real Analysis, Oxford & IBH.

Reference Books

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

Course Code	STAT 234	STATISTICAL METHODS	L	T	P	Credits
Core	MD 3	Semester III	3	1	-	3
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are:
To focus attention on various statistical methods and to apply them for basic data analysis

Expected Course Outcomes:

On the successful completion of the course, student will have
Knowledge of Index numbers, Time Series, Vital Statistics, Official Statistics
.

Unit:1

Index Numbers: Construction of index numbers; fixed and chain base index numbers; weighted index numbers; standard index numbers; Tests for index numbers; cost of living index number and its construction.

Unit:2

Vital Statistics: Methods of obtaining Vital Statistics, Methods of measuring population - Measures of mortality – Crude and specific rates, standardized rates, Infant mortality rate - Complete life table - its construction and uses. Abridged life tables.

Unit:3

Time Series Analysis: Components of a time series – methods for measurement of trend – Fitting of linear, quadratic and exponential trend – Method of moving averages

Unit:4

Official Statistics: History of Indian Statistical System - Present Indian Statistical System – Statistical system at the Central and State levels. Flow chart of Indian Statistical System – Ministry of Statistics and Programme Implementation (MOSPI) – Central Statistical Office (CSO) – National Sample Survey Organization (NSSO)

Total Lecture Hours	45 Hours

Books for Study:

1	Freedman, D., Pisani, R. and Purves, R. (2014). Statistics. 4th Edition. Norton & Comp.
2	Medhi.J. (1992) : Statistical Methods an Introductory Text , Wiley Eastern Ltd.,.
3	Kapoor.V.K. and Gupta.S. (1978): Fundamentals of Applied Statistics,Sultan Chand and Sons.

Reference Books:

1	Anderson.R, Sweeney.J and Williams.A (2002): Statistics for Business and Economics, 8/e, Thomson.
2	Sheldon M.Ross (2006): Introductory Statistics, 2/e, Elsevier Publications.
3	Murray R. Spiegel and Larry J. Stephens (2005): Schaum's Outline of Theory and Problems of Statistics, 3/e, Tata Mc Graw Hill Publishing Company Ltd, New Delhi.

Course Code	STAT 235	EXPLORATORY DATA ANALYSIS USING R	L	T	P	Credits
Core	SEC 3	Semester III	3	1	-	3
Pre-requisite		Knowledge in Basic Statistics	Syllabus Version		2023-24	

Course Objectives

This course is intended to train students to get knowledge in performing statistical data analysis using R language

Expected Course Outcomes

Students will be able to write program in R language for a various data analytic technique which will help them in getting placed in analytic companies.

Unit:1

R language Essentials: Expressions and objects, Assignments, creating vectors, vectorized arithmetic, creating matrices, operations on matrices, lists, data frames – creation, indexing, sorting and conditional selection ; examples

Unit:2

Descriptive Statistics and Graphics: Obtaining summary statistics; generating tables; Bar plots, Pie charts, Box plots, Histogram; exercises - Graphic libraries in R like GGally, RGL, ggplot2; curve fitting, performance analytics package

Unit:3

Working with Text Data: Fundamental of Text data analysis – Basic Character functions : nchar, grep, sub and gsub functions, strsplit functions – Regular expression basics and functions -

Unit:4

Detection of anomalies in the Data : Outliers and their Influence – Detecting univariate outliers – Inliers and detection – Metadata errors – Mosaic plots: Categorical scatter plots – Missing data and its Imputation

Total Lecture Hours	**45 Hours**

Books for Study

1. Tukey, J; EDA ; Book on R with examples
2. Ronald K Pearson (2018): Exploratory Data Analysis using R, CRC Press

Reference Books

1. Jared P Lander (2014): R for Everyone: Advanced Analytics and Graphics, Pearson Education Inc.
2. Navarro OT (2017); R programming by Example, Packt Publishing.
3. Wickham H and Grolemund G (2017): R for Data Science.

SECOND YEAR – SEMESTER IV

Course Code	STAT241	SAMPLING THEORY	L	T	P	Credits
Core	Major 5	Semester IV	4	1	-	4
Pre-requisite		Knowledge in Elements of Probability Theory and Probability Distributions	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To study Sample and Population and Sample survey and Census
2. To study about drawing random sample in different scenario with various sampling technique
3. Estimation of parameters (mean and variance).

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Understand the concepts and importance of properties of estimators	
2	Obtain the optimal estimator for a given parametric function	
3	Study the different methods of point estimation	
4	Observe consistent and asymptotic behaviour of estimators	
5	Construct confidence intervals for population parameters	

Unit:1

Need for sampling – population and sample – sampling unit and sample frame – Types of Population – Basic properties of population – sample survey and census – Principal steps in a Sample survey – Notion of sampling and non-sampling errors.

Unit:2

Simple Random Sampling with and without replacement – Estimation of Population mean and Proportion and their variances- Determination of sample size.

Unit:3

Stratified sampling – Principles of stratification – Estimation of population mean and its variance – Allocation techniques: optimum, proportional and Neyman – Estimation of gain due to stratification

Unit:4

Linear and Circular systematic sampling – Estimation of population mean and variance, Equal Cluster Sampling- Estimation of population mean and variance, Comparison of cluster and random sampling, Comparison of systematic, simple random and stratified

Unit:5

Illustrative numerical problems on :Use of random numbers and Simple random sampling - Stratified random sampling – Proportional allocation and Optimum allocation - Systematic sampling - Cluster sampling (equal size)

Total Lecture Hours **60 Hours**

Books for Study

1. Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley.
2. Singh D and Choudhary F.S. (1986): Theory and Analysis of Sample Survey and Designs, New Age International.
3. A.K. Swain (2003), Finite Population Sampling, South Asian Publishers

Reference Books

1. Desraj (2000): Sample survey theory, Narosa Publishing House.
2. Parimal Mukhopadhyay(2009): Theory of Sample Surveys, Prentice Hall of India

Course Code	STAT242	ESTIMATION THEORY	L	T	P	Credits
Core	MAJOR 6	Semester IV	4	1	-	4
Pre-requisite		Knowledge in Probability and Distribution Theory	Syllabus Version		2023-24	

Course Objectives

This course focuses on point and interval estimation techniques.

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Summarize the various dimensions of quality and quality improvement methods	
2	Obtain the optimal estimator for a given parametric function	
3	Study the different methods of point estimation	
4	Observe consistent and asymptotic behavior of estimators	
5	Construct confidence intervals for population parameters	

Unit:1

Basic problem of statistical Inference: Point estimation - Properties of estimators: Unbiasedness and consistency - Conditions for consistency –Sufficiency -Factorization theorem (without proof) –Simple problems

Unit:2

Efficiency -Minimum Variance Unbiased Estimators (MVUE) and their properties - Cramer-Rao Inequality - Rao - Blackwell Theorem – Simple Problems

Unit:3

Methods of Estimation: Methods of moments – Simple problems - Method of least squares – Method of minimum chi-square; Method of maximum likelihood estimation (MLE) – Properties of maximum likelihood estimators - Asymptotic properties of MLE (without proof)

Unit:4

Confidence intervals: Basic Notions - Confidence Intervals for the mean, proportion, variance (for the case of one and two populations) - Large sample Confidence Intervals

Unit: 5

Illustrative Numerical problems: Method of Moments - Method of Maximum Likelihood - Confidence Intervals

Total Lecture Hours | **60 Hours**

Books for Study

1	Hogg, R.V. , Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition
2	Rohatgi,V.K. and Saleh, A.K.(2002): An Introduction to Probability and Statistics , 2/e, John Wiley.
3	Mood,A.M., Graybill, A.M. and Boes, D.C. (2011): Introduction to theory of Statistics , McGraw Hill.

Reference Books

1	Bansilal, Sanjay Arora and Sudha Arora (2006): Introducing Probability and Statistics, 2/e, Satya Prakashan Publications, New Delhi
2	Miller, I and Miller.M (2012): Mathematical Statistics, 8/e, Pearson Education.
3	Goon, A.M., Gupta, M.K.and Das Gupta,B. (2016): An Outline of statistical theory , Vol. II , World Press, Calcutta.

Course Code	STAT243	OFFICIAL STATISTICS	L	T	P	Credits
Core	MAJOR 7	Semester IV	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

To learn about Indian Statistical System

Expected Course Outcomes

Students will get the awareness about the Indian Statistical System, Indian Administrative System in Central and States. Student will obtain the awareness about Subordinate Service and Indian Statistical Service.

Unit:1

Indian Statistical System: History of Indian Statistical System - Present Indian Statistical System – Statistical system at the Central and State levels. Flow chart of Indian Statistical System – Ministry of Statistics and Programme Implimentation (MOSPI) – Central Statistical Office (CSO) – National Sample Survey Office (NSSO)

Unit:2

Administrative Statistical System: Centralised and Decentralised Systems of Collection of Administrative Statistics – Failure of Administrative Statistical System – Weak Lateral Coordination. National Commission of Statistics (NCS) – Functions of the NCS – Constitution of NCS – National Statistical Organisation (NSO) – Functions of NSO. National Sample Survey Office (NSSO) & its Divisions.

Unit:3

The States Statistical System: Improving the Administrative Statistical System (AdSS) – Statistics for Decision Making – Operational Aspects – Computerisation of Administrative Statistics.

Directorate of Economics and Statistics (DES): Role of DES – Common Statistical Cadre – Statistical Divisions in Departments – Block Statistical Organisation.

Unit:4

Human Resource Development: Staffing Pattern at the Centre. Training Aspects – Training Courses Organised by the National Sample Survey Organization – Training arrangements at State Statistical Organisations – Subordinate Staff – Indian Statistical Service (ISS).

Total Lecture Hours | **60 Hours**

Books for Study

1. e-publication of MOSPI https://mospi.gov.in/documents/213904/0/Ch+14+30.8.2001.pdf/
2. Saluja, M.R., (1972), 'Indian Official Statistical Systems', Statistical Pub. Society.

Reference Books

1. Government of India (1999), 'Guide to Official Statistics', CSO, MOSPI.

Course Code	STAT244	NUMERICAL METHODS	L	T	P	Credits
Core	MINOR 4	Semester III	4	1	-	4
Pre-requisite		Knowledge on Basics of Calculus (at plus 2 level)	Syllabus Version	2023-24		

Course Objectives

To learn the solution of Algebraic and transcendental equations, Finite differences, interpolation techniques

Expected Course Outcomes

On the successful completion of the course, student will be able to:

Students will gain sufficient knowledge in using interpolation techniques for finding roots of polynomial equations and evaluating integrals of functions.

Unit:1

Solution of Algebraic and Transcendental Equations: Bisection method – Regula Falsi method – Iteration method - Newton Raphson method – Horner's Method Simultaneous equations: Direct methods; Gauss Elimination method – Gauss-Jordan method – Iterative methods: Gauss-Jacobi method - Gauss Siedal iterative method.

Unit:2

Finite differences: Forward and backward differences – Differences of a polynomial – Relation between the Operators E, D, δ, μ and backward difference operator, and their basic properties – Application to summation of series.

Unit:3

Interpolation with equal intervals: Newton's forward and backward differences formulae. Central differences: Gauss's forward and backward differences formulae – Stirling's, Bessel's and Laplace-Everett's formula – Simple problems only.

Interpolation with unequal intervals: Divided differences and their properties – Newton's divided difference formula – Lagrange's formula – simple problems only.

Unit:4

Inverse interpolation: Iteration or successive approximation method – Lagrange's method — simple problems. Numerical Integration: Trapezoidal rule – Simpson's 1/3 and 3/8 rules – Weddle's rule – Euler's summation formula.

Total Lecture Hours **60 Hours**

Books for Study

1. S.S.Sastry (1998): Introductory Methods of Numerical Analysis, Prentice Hall of India.
2. B. S. Grewal (1997): Numerical Methods in Engineering and Science, Khanna Publishers, India
3. M. K. Venkatraman (1999): Numerical Methods in Engineering and Science, 5/e, National Publishing company, India.

Reference Books

1. Scarborough B (2005): Numerical Mathematical Analysis, Oxford University Press.

THIRD YEAR – SEMESTER V

Course Code	STAT351	TESTING STATISTICAL HYPOTHESES	L	T	P	Credits
Core	MAJOR 8	Semester V	4	1	-	4
Pre-requisite		Theory of Estimation and Distribution Theory	Syllabus Version		2023-24	

Course Objectives: The main objectives of this course are:

1. To learn the concepts of hypotheses, Type I and Type II errors, and power of a test
2. To understand the working principle of Neyman-Pearson lemma and likelihood ratio test
3. To Formulate parametric testing problems and deriving appropriate test statistic
4. To impart knowledge on large, small sample tests based on single and two populations
5. To understand the philosophy of non-parametric test procedures.

Expected Course Outcomes: On the successful completion of the course, student will be able to:

1. Compute error probabilities, size and power of test and depict the power curve.
2. Apply Neyman-Pearson lemma to find most powerful critical region for various parametric models.
3. Use likelihood ratio test principle to derive test statistics for parametric testing problems.
4. Provide decision rules for testing hypothesis related to single and two populations.
5. Derive test statistic for non-parametric test.

Unit:1

Concept of hypothesis testing- Types of errors and power – computing error probabilities, and power – notion of most powerful tests – Statement and proof (sufficient part) of Neyman-Pearson fundamental Lemma for testing simple hypotheses on continuous distributions – Examples of Neyman-Pearson lemma to find most powerful critical region for various probability distributions.

Unit:2

Likelihood Ratio (LR) tests - Description and property of LR tests - Application to testing the mean and variance of normal distribution – testing the equality of means and variances of two independent normal distributions - small sample properties – asymptotic properties (statement only).

Unit:3

Test for single mean and variance for small and large samples – Test for specified proportion - Test for equality of means and variances of two independent populations (large and small samples) – Test for equality of proportions. Chi-square test for goodness of fit and test for independence of attributes.

Unit:4

Non-Parametric Tests - Sign test, Wilcoxon signed rank test, Median test, Mann-Whitney test, Run test, one sample Kolmogorov –Smirnov test, Chi-square test for goodness of fit (Description, properties and applications only).

Unit:5

Illustrative numerical problems on : Parametric tests – z test, t test, chi-square test - Non-Parametric Tests - Sign test, Wilcoxon signed rank test, one sample Kolmogorov –Smirnov test

Total Lecture Hours **60 Hours**

Books for Study:

1. Rohatgi,V.K. and Saleh, A.K.(2002): An Introduction to Probability and Statistics , 2/e, John Wiley.
2. Hogg, R.V., Mc Kean J W and Craig, A.T.(2005): Introduction to Mathematical Statistics, 6/e Pearson Edition.
3. Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India.

Reference Books:

1. Bansilal, Sanjay Arora and Sudha Arora (2006): Introducing Probability and Statistics, 2/e, Satya Prakashan Publications, New Delhi.
2. Gupta, S.C. and V.K. Kapoor (2000): Fundamentals of Mathematical Statistics, Sultan Chand and Co.
3. Mood,A.M., Graybill, A.M. and Boes, D.C.(1974): Introduction to Theory of Statistics , Mc Graw Hill.

Course Code	STAT352	DEMOGRAPHY	L	T	P	Credits
Core	MAJOR 9	Semester IV	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are to provide basics of demography and official statistics

Expected Course Outcomes:

On the successful completion of the course, student will be able to construct life tables and measures of population dynamics**.**

Unit:1

History of Demography, Sources, significance and errors of demographic Data, Concepts and Definitions of terms; Population census of India and Dependency Ratio; Migration; Measures of Age and Sex Composition of the Population. Rates and Ratios, Crude and Specific Rates, Standardization – Direct and Indirect Methods.

Unit:2

Introduction, Concepts, Types of Analysis: Period and Cohort Measures - Crude and Specific Rates, Standardized Rates, different Fertility Rates, Gross Reproduction Rates, Net Reproduction Rate, Replacement Index.

Unit:3

Models for population growth and their fitting to population data. – Linear, exponential, logarithmic, modified Logarithmic, logistic and gompertz.

Unit:4

Introduction, Sources and Quality of Nuptiality Data, General, Specific, Total and Standardized Marriage rates, Mean Age at Marriage, Measures of Migration: Concept of mobility and migration, sources of data, types of migration, Internal & international migrations; measures of internal migration.

Total Lecture Hours **60 Hours**

Books for Study:

1. K. Srinivasan (2011)**:** Training Manual on Demographic Techniques, United Nations Population Fund, Institute for Social and Economic Change, Bangalore.
2. Srinivasan, K. (1997): Basic demographic techniques and applications, New Delhi: SAGE.
3. Pathak, K.B. and F.Ram, (1998): Techniques of Demographic Analysis, Himalaya Publishing House, Mumbai.

Reference Books:

1. Bhende, Asha and Tara Kanitkar (1992), Principles of Population Studies – 5th Nov. ed. New Delhi, Himalaya.
2. Shryock, Henry S. Jacob S. Siegel and Associate (1980): The Methods and Materials of Demography Vol.1 & 2, U.S. Bureau of the Census, Washington D.C.
3. Preston, Samuel H, Patrick Heuveline and Michel Guillot (2000): Demography –Measuring and Modeling Population Processes.

Course Code	STAT353	STATISTICS USING R	L	T	P	Credits
Core	MAJOR 10	Semester V	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

The main objectives of this course are:

1. To Impart training in R programming, create different types of R objects and perform operations
2. To detail the construction of plots, various discrete and continuous probability distributions
5. To impart skills in analyzing univariate and bivariate data.

Expected Course Outcomes:

On the successful completion of the course, student will be able:

1. To Impart training in R programming.
2. To create different types of R objects and perform operations, construction of plots.
3. To work on various discrete and continuous probability distributions.

Unit:1

R language Essentials: Expressions and objects - creating vectors - vectorized arithmetic -creating matrices - operations on matrices – lists - data frames – creation, indexing, sorting and conditional selection – importing and exporting data files.

Unit:2

Data Visualization and Descriptive Statistics: generating tables - Bar plots - Pie chart - Box plot – Histogram – Scatter plot – line plots (single, multiple) – partitioning graphics window – adding title, labels and legends to plots - obtaining measures of central tendency, measures of location and moment based measures.

Unit:3

Probability and Distributions: sampling with and without replacement and computing combinatory - obtaining density, cumulative density and quantile values for discrete and continuous distributions - generating samples from discrete and continuous distributions - Plotting density and cumulative density curves - Q-Q plot.

Unit:4

Analyzing univariate and bivariate data: Correlation analysis - Pearson, Spearman and Kendall measures; Testing hypothesis: one and two sample tests for mean and variance, , test of significance for correlation coefficient; Regression analysis – fitting, obtaining residuals and fitted values of simple linear regression model;. Chi Square test for goodness of fit and Independence of attributes.

Total Lecture Hours **60 Hours**

Books for Study:

1. Pierre-Andre Cornillon et al. (2012): R for Statistics, CRC Press.
2. Randall E. Schumacker (2014): Learning Statistics using R, SAGE Publications, Inc.
3. Purohit, Sudha G., Gore, Sharad D. and Deshmukh, Shailaja R. (2008): Statistics using R, Alpha Science International Limited.

Reference Books:

1. Jared P Lander (2014): R for Everyone: Advanced Analytics and Graphics, Pearson Education Inc.
2. Michael J.Crawley (2007): The R Book, John Wiley and Sons Ltd.
3. Peter Dalgaard (2008): Introductory Statistics with R, 2nd edition, Springer.

Course Code	STAT 354	OPERATIONS RESEARCH	L	T	P	Credits
Core	MINOR 5	Semester V	4	1	-	4

Pre-requisite	Knowledge in Mathematics (higher secondary level)	Syllabus Version	2023-24

Course Objectives

To learn about decision theory and optimization techniques. To learn about game theory and network analysis

Expected Course Outcomes

On the successful completion of the course, student will be able to:

Students will gain knowledge to allocate resources in an optimal manner and also plan the time-line of projects

Unit:1

Introduction to Operations Research – Various Models in O.R. – Scope and limitations of O.R.– Phases of Operations Research study - Linear Programming Problem (LPP) –Formulation. Graphical solution of LPP – Simplex method – Big M-method and Two Phase method - Concepts of Duality – Conversion of Primal to Dual – Problems

Unit:2

Transportation Problem- Initial Basic Solution- North West Corner Rule, Least Cost Method and Vogel's Approximation Method – Optimal Solution by Modified Distribution Method (MODI) - Assignment problem - Simple Problems

Unit:3

Game Theory – Pure and Mixed strategies, saddle point - Dominance rule - Optimal Solution of two person zero sum games – Graphical solution of (2 x n) and (m x 2) games

Unit:4

Network analysis by CPM / PERT: Basic concepts: Construction of network - concepts of slack and float in network analysis - Determination of the floats and critical path.

Total Lecture Hours **60 Hours**

Books for Study

1. Kanti Swarup, P.K. Gupta and Manmohan (2010): Operation Research, Sultan Chand and Sons.
2. S.D. Sharma (2003): Operations Research, Kedarnath Ramnath and Co.
3. Taha H.A. (2008): Operational Research: An Introduction,8/e, Pearson.

Reference Books

1. Hillier F.S. and Libermann G.J. (2004): Introduction to Operations Research, 7thEdition, McGraw Hill

Course Code	**STAT 355**	**INTERNSHIP**	**L**	**T**	**P**	**Credits**
Core	**MAJOR 11**	**Semester V**		**2**	**3**	**4**
Syllabus Version: 2023-24						
Course Objectives						
A course requiring students to participate in professional employment related activity or work experience, or cooperative education activity with an entity external to the education institution, normally under the supervision of an employee of the given external entity.						
Expected Course Outcomes						
On the successful completion of the course, student will be able to: Students will gain skilled knowledge to allocate resources in an optimal manner and also plan the time-line of projects						

THIRD YEAR – SEMESTER VI

Course Code	STAT 361	PRINCIPLES OF EXPERIMENTAL DESIGN	L	T	P	Credits
Core	MAJOR 12	Semester VI	4	1	-	4
Pre-requisite		Knowledge in Distribution Theory and Statistical Inference	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To learn the basic principles of design of statistical experiments and models.
2. To learn about basic designs CRD, RBD, LSD and factorial design with suitable real-life examples.

Expected Course Outcomes

On the successful completion of the course, student will be able

1 To carry out one way and two-way Analysis of Variance (ANOVA)

2 To understand the basic terms used in design of experiments

3 To use appropriate experimental designs to analyze the experimental data

4 To apply Multiple range tests, the LSD test or the multiple t–test, Student-Newman-Keuls test, Duncan's multiple range test, Tukey's test, Multiple F tests, Fisher's least significant difference test

5 To analyze 2^2 and 2^3 factorial experiments and give statistical interpretation of the experimental results

Unit:1

Analysis of variance: Definition, assumption for ANOVA test, one-way and two-way classifications for fixed effect model with one observation per cell. Introduction to design of experiments: terminology, experiment, treatment, experimental units, blocks, experimental error, replication, precision and accuracy, need for design of experiment, size and shape of plots and blocks.

Unit:2

Fundamental principles of design of experiments: Randomization, Replication and Local control, Completely randomized design (CRD), Randomized Complete Block Design (RCBD), Latin square design (LSD) and their layout and analyses.

Unit:3

Missing plot technique for RCBD and LSD, missing plot techniques for one observation per cell in RCBD. Multiple Comparison tests: Least Significant Difference (LSD), Tukey's test, Duncan's Multiple Range test (DMRT), Student Newman Keul Test (SNK)

Unit:4

Factorial Experiments: 2^2, 2^3 designs -Estimation of main effects and interactions and their standard errors – Analysis of 2^2, 2^3 designs

Unit:5

Illustrative numerical problems on Completely Randomized Design - Randomized Block Design - Latin Square Design - 2^2 Factorial Design - 2^3 Factorial Design

Total Lecture Hours | **60 Hours**

Books for Study

1. Das, M.N. and Giri.N.C. (1986): Design and Analysis of Experiments, Wiley eastern.
2. Montgomery, C.D (2017): Design of Experiments, 9/e, John Wiley and Sons.
3. Cochran .W.G. and Cox .G.M. (1995): Experimental designs, 4/e, Wiley.

Reference Books

1. Goon.A.M, Gupta and Dasgupta.B.(2001): An Outline of statistical Theory, Vol. II, 6/e World Press Calcutta.
2. Gupta .S.C. and Kapoor.V.K.(2000): Fundamentals of Applied Statistics, Sultan Chand.
3. ParimalMukhopadhyay(2005):Applied Statistics, 2/e, Books and Allied (P) Ltd, Kolkata.

Course Code	STAT362	ACTUARIAL STATISTICS	L	T	P	Credits
Core	MAJOR 13	Semester VI	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives:

1. modelling of individual and aggregate losses.
2. fitting of distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance.
3. finding distribution of aggregate claims, compound distributions and their applications

Expected Course Outcomes: On the successful completion of the course, student will be able to:

1. handling problems on joint life and last survivor status and multiple decrement model
2. calculation of various payments from life tables using principle of equivalence, net premiums, prospective and retrospective provisions/reserves
3. real illustrations for the concepts mentioned above through laboratory assignments.

Unit:1

Probability Models and Life Tables, Loss distributions: modelling of individual and aggregate losses, moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance. Risk models models for individual claims and their sums, Distribution of aggregate claims, Compound distributions and applications, Introduction to credibility theory

Unit:2

Survival function, curtate future lifetime, force of mortality. Multiple life functions, joint life and last survivor status. Multiple decrement model. Life Contingencies: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor.

Unit:3

Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments.

Unit:4

Calculation of various payments from life tables: principle of equivalence, net premiums, prospective and retrospective provisions/reserves

Total Lecture Hours | **60 Hours**

Books for Study

1. Boland, P. (2007). Statistical and Probabilistic Methods in Actuarial Science. Chapman and Hall/CRC.
2. Borowaik, D.S. and Shapiro, A. F. (2013). Financial and Actuarial Statistics: An Introduction. 2nd Edition. Marcel Dekker Inc., New York-Basel.
3. Bowers, N. L., Gerber H. U., Hickman, J. C., Jones, D. A. and Nesbitt, C. J. (1997). Actuarial Mathematics, 2nd Edition, Society of Actuaries, USA.

Reference Books

1. Deshmukh, S.R. (2005). Actuarial Statistics: In Introduction Using R. Narosa Publishing House, New Delhi
2. Promislow, S. D. (2014). Fundamentals of Actuarial Mathematics. 3rd Edition. Wiley

Course Code	STAT363	INTRODUCTORY STATISTICS USING PYTHON	L	T	P	Credits
Core	MAJOR 14	Semester VI	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To learn about basics of python.
2. To learn visualizing the data.
3. To know about the data handling and performing inferential tests

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Understand how to install, perform basic operations	
2	To visualize data using various codes and filters	
3	Inferential aspects of testing means and variances	
4	Model fit and residual analysis	
5	Carry out analyses of multivariate techniques using various datasets	

Unit:1 Introduction to Python

Introduction to Python – Installation – Basic Object types and Operators: Arithmetic, relational, logical, membership, identity – Control Structure: Selection and iteration – Lists – Tuple – sets – Dictionary – creation, deletion, updation – file I/O operations

Unit:2 Data Handling Tools

Data Analysis Packages: NumPy- creating NumPy array- indexing – slicing- arithmetic operations – Pandas: Creating series and Data frame – reading and writing from csv, text, excel files – summary statistics – merging, join and grouping – pivot tables

Unit:3 Data Visualization Tools

matplotlib: line plots - multiple lines on same axis and different axis, scatter plots, histograms, customize 37abelling – bar charts: simple, stacked and multiple -Pie charts. Perspectives in Data: creating a dummy variables, normalizing and scaling data

Unit:4 Inferential Procedures and Model Fitting

Hypothesis Testing procedures: t, F and Chi-square – construction of confidence intervals – simple linear fitting and residual analysis – prediction intervals

Total Lecture Hours **60 Hours**

Books for Study

1	Manohar Swamynathan (2017), Mastering Machine Learning with Python in Six Steps, Apress
2	Tom M. Mitchell (2017), Machine Learning, Tata McGraw Hill

Reference Books

1	William McKinney (2017), Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, O'Rilley

Course Code	STAT 364	STATISTICAL QUALITY CONTROL	L	T	P	Credits
Core	MAJOR 15	Semester VI	4	1	-	4
Pre-requisite		Knowledge in Elements of Probability Theory and Probability Distributions	**Syllabus Version**			2023-24

Course Objectives

The main objectives of this course are to:

1. To Impart knowledge on the concepts of quality improvement and process control techniques
2. To make learners understand the working principle of control charts for variables and attributes
3. To detail the construction of control charts
4. To impart skills in drawing and analyzing control charts
5. To understand the operating procedure and analysis of acceptance sampling plans

Expected Course Outcomes

On the successful completion of the course, student will be able to apply quality control tools and techniques to observe the change in the process and product control.

Unit:1

Concept of quality of a product and quality improvement – Dimensions of quality – Statistical methods for quality control and improvement – acceptance sampling, process control and designed experiments – link between quality and productivity – Modelling variation – Stem and leaf plot, histogram and box plot

Unit:2

Statistical process control – chance and assignable causes of variations – seven magnificent tools of statistical process control – general theory of control charts – statistical basis of control charts – basic principles and choice of control limits – 3-Sigma control limits, warning limits and specification limits – OC function of control chart and average run length – sensitizing rules for control charts.

Unit:3

Control chart for variables – $\bar{X}$, R and S – chart – their construction and analysis – Control charts for attributes – p, np, c and u charts – their construction and analysis

Unit:4

Lot by lot acceptance sampling for attributes – acceptance-sampling problem – advantages and limitations – types of acceptance sampling plans – Single sampling plan, Double sampling plans – derivation and construction of OC – rectifying inspection plan – construction of AOQ, AOQL, ATI and ASN functions – notion of sequential sampling plan, Solve problems using Excel.

Unit:5

Illustrative numerical problems on : $\bar{X}$, R, p, c charts - Single sampling plan, Double sampling plans – OC function, AOQ, ATI and ASN

Total Lecture Hours | **60 Hours**

Books for Study

1. Montgomery, C. Douglas (2019): Introduction to Statistical Quality Control, 8/e, John Wiley and Sons.
2. S.C.Gupta and V.K.Kapoor (2014), Fundamentals of Applied Statistics, Sultan Chand and Sons.

Reference Books

1. Duncan, A.J. (1986). Quality Control and Industrial Statistics, 5th Edition, Irwin
2. Grant.E.L. and Leavenworth.R.S. (2017), Statistical Quality Control, 7/e, McGraw Hill.

Course Code	STAT365	BASIC ECONOMETRICS	L	T	P	Credits
Core	MINOR 6	Semester VI	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

To learn the concepts in Econometrics

Expected Course Outcomes

On the successful completion of the course, student will be able to deal with various consequences and issues that arise in econometric models.

Unit:1

Nature and Scope of Econometrics - Review of General Linear Model (GLM), Ordinary Least Squares (OLS), Generalized Least Squares (GLS) and Multicollinearity – Sources, consequences and detection

Unit:2

Heteroscedasticity - consequences and detection: Graphical methods – Tests: Park test – Glejser's test – Spearman's rank Correlation test – Goldfeld-Quandt test – Breusch-Godfrey-Godfrey test and White's General Heteroscedasticity test – remedial measures for Heteroscedasticity – Weighted Least Squares approach

Unit:3

Autocorrelation – consequences and tests: Run's test –Durbin-Watson test - - Autoregressive linear regression - Distributed lag models – Finite and Infinite Distributed lag models – Koyck's approach, Almons' Model, Cagan's approach, Arithmetic Lag, Geometric Lag model

Unit:4

Simultaneous linear equations model - Identification problem - Restrictions on structural parameters - rank and order conditions - Restrictions on variances and covariances - Estimation in simultaneous equations model

Total Lecture Hours **60 Hours**

Books for Study

1. Gujarati, D.N. , Dawn C Porter and Manoranjan Paul (2019): Basic Econometrics, 6/e, McGraw Hill.
2. Johnston, J. (1996): Econometric methods, Third edition, McGraw Hill.

Reference Books

1. Apte, P.G. (1990): Text book of Econometrics. Tata McGraw Hill.
2. Intrulligator, M.D. (1980): Econometric models - Techniques and Applications, Prentice Hall of India.
3. Kleiber, C. and Zeileis, A. (2008): Applied Econometrics with R, Springer, NY.

FOURTH YEAR – SEMESTER VII

Course Code	STAT471	ADVANCED PROBABILITY THEORY	L	T	P	Credits
Core	MAJOR 16	Semester VII	4	1	-	4
Pre-requisite		Basic Probability Theory	Syllabus Version		2023-24	

Course Objectives

The objective for this course is to learn the theory and methods of probability theory, and be able to apply and communicate them in practice.

Expected Course Outcomes

A student will be able to: Recognize the role of probability theory in the sciences, communicate the ideas and results of probability; Graduate students will also be able to formulate and apply the definitions of convergence in distribution and in probability, formulate scientific problems involving randomness in mathematical terms, and use probability in their careers.

Unit:1

Algebra of sets - fields and sigma-fields, Inverse function – Measurable function – Probability measure on a sigma field – simple properties - Probability space - Random variables and Random vectors – Induced Probability space – Distribution functions – Decomposition of distribution functions.

Unit:2

Expectation and moments – definitions and simple properties – Moment inequalities – Holder, Jenson, Chebyshev, Markov Inequalities– Characteristic function – definition and properties – Inversion formula.

Unit:3

Convergence of a sequence of random variables - convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean - Weak convergence of distribution functions – Slustky theorem - Helly-Bray theorem. Definition of product space – Fubini's theorem (statement only) - Independence of two events – Independence of classes – Independence of random variables – properties – Borel zero –one law.

Unit:4

Law of large numbers - Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (statement only) – Central Limit Theorem – Lindeberg – Levy theorem, Linderberg – Feller theorem (without proof), Liapounov theorem (without proof) – Relation between Liapounov and Linderberg – Feller forms – Radon Nikodym theorem and derivative (without proof) – Conditional expectation – definition and simple properties.

Total Lecture Hours | **60 Hours**

Books for Study

1. Bhat, B. R. (2007): Modern Probability Theory, 3rd edition, New Age International Pvt. Ltd.
2. Ash, R.B. (1972): Real Analysis and Probability, Academic Press.
3. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley
4. Athreya K B and Lahiri S N (2005):Measure Theory, Hindustan Book Agency.

Reference Books

1. Basu A K. and A Bandopadhyay (2012): Measure Theory and Probability, PHI Learning Pvt. Ltd.
2. Tucker, H.G. (1967): A Graduate course in Probability, Academic Press
3. Chow, Y.S. and Teicher, H. (1979): Probability Theory, Springer
4. Billingsley P (1995): Probability and Measure, Wiley.

Course Code	STAT472	ADVANCED DISTRIBUTION THEORY	L	T	P	Credits
Core	MAJOR 17	Semester VII	4	1	-	4
Pre-requisite		Knowledge in Probability Theory	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To learn the theory and applications of some important univariate and bivariate distributions
2. To learn advanced distribution theory concepts like Compound, Truncated, Mixture, Non-central sampling distributions, about Quadratic forms and its distribution and Order Statistics

Expected Course Outcomes:

1 Knowledge to understand the concepts and importance of univariate and bivariate distributions

2 Knowledge of Compound, Truncated, Mixture distributions and their applications

3 To know Multivariate Normal distribution and no-central sampling distributions

4 The ability to learn about distribution of quadratic forms and its applications

5 To learn the concept of order statistics, its distribution and properties

Unit:1

Distribution of functions of random variables - Cauchy, Inverse Gaussian, Lognormal, Logarithmic series and Power series distributions - Multinomial distribution

Unit:2

Bivariate Binomial – Bivariate Poisson – Bivariate Normal- Bivariate Exponential of Marshall and Olkin; Compound, Truncated distributions - Binomial, Poisson, Normal and Exponential

Unit:3

Multivariate normal distribution (Definition and Concept only) - Sampling distributions: Non-central chi-square, t and F distributions and their properties - Distributions of quadratic forms under normality-independence of quadratic form and a linear form - Cochran's theorem

Unit:4

Order statistics, their distributions and properties- Joint and marginal distributions of order statistics - Distribution of range and mid range – Simple problems

Total Lecture Hours | **60 Hours**

Books for Study

1. Johnson, N.L,Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol.1 &2, Wiley Series in Probabilty and Statistics.
2. Johnson, N.L , Kemp A.W. &Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probabilty and Statistics
3. Rohatgi, V.K. and Saleh, A.E. (2008). An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
4. David H. A. and Nagaraja H.N.(2003): Order Statistics, 3/e, John Wiley & Sons.
5. Kocherlakota S and Kocherlakota K(1992): Bivariate Discrete distributions, M. Dekker.

Reference Books

1. Goon, A.M., Gupta, M.K. and Das Gupta,B. (2013): Fundamentals of Statistics, Vol. II, WorldPress, Calcutta.
2. Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
3. Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.

Course Code	STAT473	STATISTICAL INFERENCE-I	L	T	P	Credits
Core	MAJOR 18	Semester VII	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

To provide a systematic account of Neyman Pearson theory of testing and closely related theory of point estimation and confidence sets, together with their applications

Expected Course Outcomes

On the successful completion of the course, student will be able to learn estimation and testing techniques

Unit:1

Estimation: Concept of unbiasedness, sufficiency, consistency, efficiency, completeness – Exponential and Pitman family of distributions - Minimum and uniformly minimum variance unbiased estimator - Fisher information measure - Cramer- Rao inequality - Chapman-Robin inequality - Bhattacharya bounds (univariate and multivariate case)

Unit:2

Rao-Blackwell and Lehmann-Scheffe theorems - Ancillary statistic - Basu's theorem and its applications - Methods of estimation: method of moments, maximum likelihood estimation, minimum chi-square method, method of scoring.

Unit:3

Consistent Asymptotic Normal (CAN) estimators and their properties – Delta method - Invariant estimation - Location and scale invariant estimators - Pitman's method for obtaining location and scale invariant estimators.

Unit:4

Interval estimation: Construction of confidence intervals using pivots - Shortest expected length confidence interval – Large sample confidence intervals - Concept of Bayes estimation and Minimax estimator – Loss and risk functions – Simple problems.

Total Lecture Hours **60 Hours**

Books for Study

1	Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI
2	Casella G and Berger R L (2007): Statistical Inference, 2/e, Duxbury Press, Belmont. USA
3	Kale B.K. and Muralidharan (2005), A first Course on Parametric Inference, Narosa Publishing House.

Reference Books

1	Lehmann, E.L. (1986) : Theory of Point Estimation (Student Edition). John Wiley & Sons.
2	Zacks, S.(1971) : Theory of Statistical Inference, John Wiley and Sons. New York
3	Goon, A.M., Gupta, M.K. & Dasgupta, B (2016): An Outline of Statistical Theory, Vol-II.
4	Srivastava MK, Khan AH and Srivastava N (2014): Statistical Inference: Theory of Estimation. PHI

Course Code	STAT474	ADVANCED SAMPLING THEORY	L	T	P	Credits
Core	MINOR 7	Semester VII	4	1	-	4
Pre-requisite		Knowledge of Introduction to sampling theory	Syllabus Version		2023-24	

Course Objectives

The objectives of this course are to teach basic ideas of sampling from an applied perspective and to provide uses in real life problems. To introduce the methods of drawing samples using random sampling and probability proportional to size sampling. To introduce methods of sampling for small and large scale surveys. To introduce randomize techniques for response and non-response sample survey. Estimation of population parameters.

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Needs of basic and advance concepts and importance of sampling methods	
2	Apply the existing ideas of sampling methods to draw samples or sample surveys	
3	To understand unbiased / biased properties of estimators and unbiased estimate of sampling variance	
4	Applying these methods for real life problems and Analyze the estimator behaviours to real data sets	

Unit:1

Review of Preliminary Sampling Techniques, Cluster Sampling (equal / unequal) – Estimators of mean and variance – Multistage Sampling Technique: Two stage (equal / unequal) – variance of the estimated mean – Double Sampling for stratification and Ratio estimator.

Unit:2

Probability Proportional to Size (PPS) sampling- Procedure for selecting PPS sample (WR and WOR) - Inclusion Probabilities – PPSWOR- Des-Raj's ordered estimator and Horvitz-Thompson, Yates –Grundy Form and Murthy's unordered estimators.

Unit:3

Ratio estimators and their properties in Simple Random Sampling – Ratio estimators in Stratified Random sampling – Regression Estimators, Regression estimators in Stratified Random Sampling – Multivariate Ratio estimators and Multivariate Regression Estimators

Unit:4

Randomized response methods – Warner's, Simmon's and Two Stage response methods – Sources of errors in Surveys –Mathematical model for the effects of call-backs and the errors of measurement – Non-sampling errors – Sources, types and their components

Total Lecture Hours | **60 Hours**

Books for Study

1	Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley Eastern Ltd,
2	Singh, D. and Choudhary, F.S (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd,
3	Sukhatme PV., Sukhatme BV., Sukhatme S. and Asok C. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and ISARI Publications, New Delhi

Reference Books

1	Desraj and Chandhok P.(1998): Sampling Theory, Narosa Publications, New Delhi
2	Steven K Thompson (2012): Sampling, 3/e, Wiley
3	Murthy, M.N (1979): Sampling Theory and Methods, Statistical Publishing Society, Calcutta
4	Sarjinder Singh (2004): Advanced Sampling – Theory with Applications, Kluwer Publications

Course Code	STAT475	REGRESSION ANALYSIS	L	T	P	Credits
Core	MINOR 8	Semester VII	4	1	-	4
Pre-requisite		Statistical Inference	Syllabus Version		2023-24	

Course Objectives

1. To describe multiple linear regression model and estimation of the parameters involved.
2. To imbibe theoretical skills in deriving results
3. To understand model diagnostics and validation techniques
4. To disseminate the diagnostic and remedial measures of collinearity
5. To provide a conceptual understanding of non-linear and robust regression

Expected Course Outcomes : On the successful completion of the course, student will be able to:

1	Derive estimators of the model parameters and perform hypothesis testing	
2	Compute prediction and confidence intervals.	
3	Learn about residual diagnostics and identify influential observations	
4	Explain the cause, consequences and remedial measures of collinearity	
5	Conceptualize non-linear, robust and non-parametric regression.	

Unit:1

Multiple linear model - assumptions – least square estimators of the parameters and their properties – Gauss-Markov theorem – Model in centered form – Likelihood estimation of the regression under normality assumption and their properties – measures of model fit – Generalized least squares – misspecification of the error structure – model over- and under- fitting – its consequences.

Unit:2

Test for overall regression and for a subset of the slope parameters – test in terms of R2 – General Linear Hypothesis testing – special cases – confidence interval for the parameters – prediction intervals – hat matrix and its properties – study of residuals, outliers and influential observations

Unit:3

Model building and variable selection – Criteria for evaluating subset regression model – Variable selection algorithms – Stepwise regression, Forward selection and backward elimination – Collinearity diagnostics – Causes, Consequences and Remedy.

Unit:4

Introduction to general non-linear regression – Least squares in non-linear case – Estimating the parameters using Linearization - Non-linear growth models – Concept of non-parametric regression – nearest neighbour method - Robust regression – Least absolute deviation regression – M estimator and its properties.

Total Lecture Hours | **60 Hours**

Books for Study

1	Alvin C. Rencher (2000): Linear Models in Statistics, John Wiley & Sons, New York (Chapters 7,8 & 9 for Unit I & II)
2	Draper, N and Smith, H (1998): Applied Regression Analysis, 3rd Edition, Wiley-Interscience.
3	Montgomery, D. C., Peck, E. A. and Vining, G. G. (2013): Introduction to Linear Regression Analysis, 5thEditio,.Wiley

Reference Books

1	Chaterjee, S, Ali S. Hadi (2013): Regression Analysis by Example, 5thEdition, John Wiley and Sons.
2	Searle, S.R. (1997): Linear Models, John Wiley
3	Thomas P.Ryan(2006): Modern Regression Methods, John Wiley and Sons.
4	Seber G.A.F and Wild C.J. (2003): Nonlinear Regression, John Wiley and Sons

FOURTH YEAR – SEMESTER VIII

Course Code	STAT481	STATISTICAL INFERENCE II	L	T	P	Credits
Core	MAJOR 19	Semester VIII	4	1	-	4
Pre-requisite			Syllabus Version	2023-24		

Course Objectives

1. To learn Neyman – Pearson principle and derive most and uniformly most powerful tests
2. To obtain test procedures for distributions under exponential class of family
3. To formulate tests in the presence of nuisance parameters
4. To impart knowledge on invariant and likelihood ratio test methods
5. To understand the philosophy of non-parametric test procedures

Expected Course Outcomes: On the successful completion of the course, student will be able to

1	Derive critical regions for tests involving simple and composite hypotheses using Neyman-Pearson lemma
2	Obtain test statistics under unbiased and similar tests
3	Use likelihood ratio test principle to derive test statistics for parametric testing problems
4	Derive maximal invariant test functions
5	Conceptualize the working principles of various non-parametric tests

Unit:1

Test function - Randomized and non-randomized tests - Most powerful test - Neyman – Pearson fundamental lemma – examples - Uniformly most powerful test - Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma (statement only) and its applications

Unit:2

Unbiasedness in hypothesis testing - Uniformly most powerful unbiased tests - Unbiased tests for one parameter exponential family – examples - Similar test and complete sufficient statistic - Similar tests with Neyman structure - Locally most powerful tests

Unit:3

Maximal statistic and Invariant tests - Uniformly most powerful invariant tests - Likelihood ratio (LR) test - properties - asymptotic distribution of LR statistic - Applications of the LR tests.

Unit:4

Non-parametric tests - Kolmogorov Smirnov one and two sample tests - Wald-Wolfowitz run test, Mann-Whitney U test - Kruskal Wallis test - Friedman's test - Sequential tests - structure of sequential tests – Sequential Probability Ratio Test - determination of the boundary constants – examples.

Total Lecture Hours: 60 Hours

Books for Study

1	Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi.
2	Lehmann, E.L and Joseph P. Romano (2005): Testing Statistical Hypotheses, 3rd Edition, Springer
3	Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India
4	Gibbons, J.D. (1985): Non Parametric Statistical Inference, 2nd Edition , Marckel Decker

Reference Books

1	Casella, G & Berger, R.L (2007): Statistical Inference, Duxubury Press, Belmont. USA
2	Ghosh, B.K (1970): Sequential Tests of Statistical Hypotheses, Addison Wesley
3	Parimal Mukhopadhyay (2006): Mathematical Statistics, 3rd Edition, Books & Allied (P) Ltd, Kolkata

Course Code	STAT482	MULTIVARIATE STATISTICAL ANALYSIS	L	T	P	Credits
Core	MAJOR 20	Semester VIII	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To learn about multivariate normal distribution and its characterizations.
2. To study the multivariate tests for mean vectors and covariance matrices.
3. To know the concepts and applications of multivariate statistical methods like Discriminant Analysis, Principal Component Analysis, Canonical Correlation Analysis & Factor Analysis

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Understand the concepts and applications and multivariate normal distribution	
2	Inferential aspects of testing mean vectors and covariances matrices	
3	Perform modelling to classify the data into k populations	
4	Perform dimensionality reduction of data into meaningful components	
5	Carry out analyses of multivariate techniques using various datasets	

Unit:1 Multivariate Data and Multivariate Normal Distribution

Multivariate normal distribution– Marginal and conditional distributions – characteristic function. Maximum likelihood estimation (MLE) of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known

Unit:2 Testing of Mean Vectors and Covariance Matrices

Hotelling T^2 statistic - derivation and its distribution – Uses of T^2 statistic –Mahalanobis D^2 statistic and its distribution - Relation between T^2 and D^2- Generalized variance – Wishart distribution (statement only) – Properties of Wishart distribution – Test for single covariance matrix – Test for equality of covariance matrices – One way Multivariate Analysis of Variance (MANOVA)

Unit:3 Classification Models

Classification problems – Classification into one of two populations (known and unknown dispersion matrix) – Classification into one of several populations – Fisher's Linear discriminant function

Unit:4 Dimensionality Reduction Techniques

Principal components – Properties - Extraction of Principal components and their variances Canonical correlation – Estimation of canonical correlation and variates - Factor analysis – Mathematical model - Estimation of Factor Loadings – Concept of factor rotation – Varimax criterion

Total Lecture Hours 60 Hours

Books for Study

1	Anderson, T.W. (2009): An Introduction to Multivariate Statistical Analysis, 3/e, Wiley.
2	Johnson, R. A and. Wichern D.W (2015): Applied Multivariate Statistical Analysis, 6/e, Pearson Education India.
3	Alvin C. Rencher (2012): Methods of Multivariate Analysis, 3/e, Wiley.

Reference Books

1	Narayan C. Giri (2003): Multivariate Statistical Analysis: Revised and Expanded, 2/e, CRC Press
2	K.C. Bhuyan (2008): Multivariate Analysis and Its Applications, New Central Book Agency

Course Code	STAT483	DESIGN OF EXPERIMENTS	L	T	P	Credits
Core	MAJOR 21	Semester VIII	4	1	-	4
Pre-requisite		Knowledge in Distribution Theory & Statistical Inference	Syllabus Version			2023-24

Course Objectives

The main objectives of this course are to:

1. Understand the need of experimental design, understand the link between linear models and design of experiments.
2. Understand the basic designs, factorial designs, incomplete block designs and their analysis

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	To know the General Linear Hypothesis model, design matrix, C matrix and its properties
2	To estimate the missing values in RBD, LSD and carry out the analysis
3	To learn the analysis of confounded 2n and 3nfactorial experiments and fractional factorial experiments
4	To know the analysis of incomplete block designs : BIBD, PBIBD(2), Split plot and Strip plot designs
5	To understand and use appropriate experimental designs to analyze the experimental data.

Unit:1

Notion of design matrix - General analysis of design models (Intra Block analysis)- C Matrix and its properties - Expected Mean Squares (EMS) and its uses - Algorithm for calculating EMS - Two-way elimination of heterogeneity - Block Designs: Connectedness, balancing, Orthogonality, Efficiency, Resolvable designs

Unit:2

Basic Designs: Overview of Completely Randomized Design (CRD), Randomized Block Design (RBD) with more than one observation per cell and Latin Square Design (LSD) – Derivation of one and two missing values, Iterative and non-iterative methods – Loss of Efficiency due to missing values - Factorial experiments: 2n and 3n experiments and their analysis

Unit:3

Confounding - Complete and Partial Confounding in 2n and 3n experiments - Fractional Replication in Factorial Experiments – Split plot and strip plot designs and their analysis

Unit:4

Incomplete Block Designs - Balanced Incomplete Block Design (BIBD)- Types of BIBD - Simple construction methods - Inter and Intra Block analysis of BIBD – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only

Total Lecture Hours | **60 Hours**

Books for Study

1	Das, M.N. and Giri.N.C. (1986): Design and Analysis of Experiments, Wiley Eastern.
2	Montgomery, C.D (2017): Design of Experiments, 9/e, John Wiley and Sons.
3	Cochran .W.G. and Cox .G.M. (1995): Experimental designs, 4/e, Wiley.
4	Searle, S.R(1987) : Linear Models, John Wiley and Sons.

Reference Books

1	Kabe D. G. and Gupta A. K. (2007): Experimental Designs: Exercises and Solutions, Springer-Verlag, New York
2	Klaus Hinkelmann and Kempthorne, O. (1994): Design and Analysis of Experiments, John Wiley and Sons.
3	ParimalMukhopadhyay(2005): Applied Statistics, 2/e, Books and Allied (P) Ltd, Kolkata.

Course Code	STAT484	STOCHASTIC PROCESSES	L	T	P	Credits
Core	MAJOR 22	Semester VIII	4	1	-	4
Pre-requisite			Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to

1. Explain the concept of stochastic process which students need for their experiment and research.

Provide the classification and properties of stochastic processes, discrete and continuous Markov chains, Brownian motion, renewal process, stationary processes and branching process.

2. Focus on theoretical concepts pertaining to handling various stochastic models.
3. Impart the application of various stochastic models for forecasting and prediction

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	Apprehend the concept of stochastic process, its specifications, and analyze the classification of states; construct Markov Chain for real world situations
2	Understand Continuous time Markov processes and obtain the birth and death processes; explore their applications to various practical problems.
3	Explore the concept of Stationary processes in univariate and multivariate scenarios; derive the properties of auto-covariance and autocorrelation functions.
4	Determine renewal process, renewal function, distribution of arrival and inter arrival times and renewal policy under varied conditions

Unit:1

Introduction of Stochastic Processes- Specifications of a stochastic processes - Classification of stochastic processes - Markov chains -Classification of states and chains - Higher transition probabilities and its limiting behaviour -Chapman Kolmogorov's equations - Stationary distribution - Ergodic theorem - One dimensional random walk and Gambler's ruin problems.

Unit:2

Continuous Time Markov Processes- Poisson processes and related distributions - Birth and death processes – Kolmogorov-Feller differential equations of birth and death processes - Applications to queues and storage problems and Wiener process

Unit:3

Stationary Processes- Weakly stationary and strongly stationary processes - Properties of auto covariance and auto correlation functions - Autoregressive and Moving average processes - Spectral density function - Spectral representation of moving average processes

Unit:4

Renewal Theory- Renewal equation - Stopping time - Wald's equation - Elementary renewal theorem and its applications - Renewal reward processes - Residual and Excess life times - Markov renewal and Semi Markov processes.

Total Lecture Hours | **60 Hours**

Books for Study

1	Medhi, J. (2020): Stochastic Processes, New Age International Publishing Limited, New Delhi.
2	Karlin, S. and Taylor, H.M (1975): A First Course in Stochastic Processes – Vol. I. Academic Press, New York.

Reference Books

1	Cinlar, E. (2013): Introduction to Stochastic Processes, Courier Dover Publications.
2	Cox, D.R. and A.D. Miller (1984): The Theory of Stochastic Processes, Chapman & Hall
3	Linda J.S. Allen (2011). An Introduction to Stochastic Processes with Applications to Biology, Second Edition, Chapman & Hall/CRC
4	Papoulis, A. and Pillai, U.S. (2006). Probability, Variables and Stochastic Processes (Fourth Edition). Tata McGraw-Hill.
5	Resnick, S. (1992): Adventures in Stochastic Processes, Birkhauser, Boston. (Reprint 2005).
6	Tjims, H.C. (2003): A First course in Stochastic Models, John Wiley & Sons, New Delhi.

Course Code	STAT485	RELIABILITY THEORY	L	T	P	Credits
Core	MAJOR 23	Semester VII	4	1	-	4
Pre-requisite		Knowledge in Probability Distributions	Syllabus Version		2023-24	

Course Objectives

The main objectives of this course are to:

1. To study components and system and its structure
2. Measures of Reliability and Life time experiments and deriving life testing data
3. Construction of Reliability models
4. Estimation of reliability parameters and predictions

Expected Course Outcomes

On the successful completion of the course, student will be able to:

1	To aware the objectives, needs and applications of reliability and ideas of structural reliability.
2	To understand the statistical measures and life distributions in reliability
3	To Study different ageing properties and deriving life distribution for reliability operation.
4	Estimation of reliability parameters and other associated concepts.
5	To analyze the concepts of reliability data

Unit:1 Structural Reliability

Introduction of reliability; Structural properties of coherent system: components and systems, coherent structures, representation of coherent systems in terms of paths and cuts, relevant & irrelevant structure; Modules of coherent systems; Reliability of a coherent systems; Reliability importance of components; Bounds on System Reliability.

Unit:2 Measures of Reliability and Common Life distributions

Definition of reliability function-measures of reliability-pdf, cdf and, hazard or failure rate function, MTTF, MTBF, Mean Residual life and Bathtub hazard function-simple problems. Concept of Lifetime and Life distributions- Some common life distributions-Exponential-Weibull-Rayleigh-Gamma-lognormal-simple problems for reliability measures

Unit:3 Ageing Properties of Life Distribution

Notions of Ageing: Classes of life distributions and their duals - preservation of life distribution classes for reliability operation - Formation of coherent systems, convolutions and mixtures, Hollander –Proschan and Despande tests for exponentiality

Unit:4 Estimation of lifetime and other related techniques

Concepts of life time data-complete and censored (left and right)-type-I and type-II samples, Likelihood Formulation for censoring, MLE of reliability parameters using common life distribution referred in unit-II, Probability plotting technique, Total time of test, basic concepts of accelerated life testing

Total Lecture Hours **60 Hours**

Books for Study

1	Barlow, R.E. and Proschan F. (1985) Statistical Theory of Reliability and Life Testing; Rinehart and Winston.
2	Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.
3	Michael S. Hamada, Alyson G. Wilson, C. Shane Reese, Harry F. Martz(2008): Bayesian Reliability, Springer
4	Deshpande JV and Purohit SG (2015): Lifetime Data: Statistical Models and Methods, World Scientific Publishing Co. Pte Ltd, Singapore

Reference Books

1	Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
2	Nelson, W (1982): Applied Life Data Analysis; John Wiley
3	Zacks, S(1992): Introdcution to Reliability Analysis, Springer Verlag.
4	Marshall, A.W. and Olkin I(2007): Life Distributions, Springer

Syllabus for Pre Ph.D.-Examination in Statistics
STAT 901: Research Methodology

UNIT-I:

Research Methodology: An Introduction - Meaning of Research, Objectives of Research**,** Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India. **Defining the Research Problem** - What is a Research Problem? Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem.

UNIT-II:

Interpretation and Report Writing - Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

UNIT-III:

Law of large Numbers (IID and Non-IID cases)-Distribution function and methods of transformations of random variables, Generating Function: Probability, Moment and Characteristic functions for univariate set up. Probability distributions: Exponential; Multinomial, Multivariate normal, Weibull distributions-properties and characterizations.

UNIT-IV:

Estimation-Classical and Bayesian Approach, Methods of Estimation-Moment, Likelihood and EM Algorithm-Properties and related problems- Prior distribution: Conjugate , informative and non-informative priors, Loss function-SELF, LINEX Loss function, Risk functions-Problems.

UNIT-V:

Generating random samples using probability integral transformation – accept/reject algorithm – metropolis algorithm, Gibbs sampling, Monte Carlo integration, MCMC principle – Metropolis Hasting algorithm, Bootstrap methods.

Books for Study:

For Unit-I and II

Kothari, C.R. and Gaurav Garg(2024). Research Methodology: Methods and Techniques. 5th ed. New Age International Publishers. [Relevant sub-titles under Chapters 1, 2 and 19].

For Unit-III and IV

Rohatgi, V. K. and Md. Ehsanes Saleh, A. K. (2015). An introduction to probability theory and mathematical statistics, John Wiley & Sons. [Relevant sub-titles under Chapters 2, 3, 7and 8].

For Unit-V

Robert, C.P., and Casella, G. (2004), Monte Carlo Statistical Methods, Springer. [Relevant sub-titles under Chapters 2, 3, 7 and 9]

Syllabus for B. Tech. courses under NEP programme

PROBABILITY AND STATISTICS

Unit I – Basic Statistics

Measures of Central Tendency and Dispersion in Frequency Distributions – Summary Statistics – Measure of Central Tendency – Arithmetic mean – Weighted Mean – Geometric Mean – Median – Mode – Dispersion – Average Deviation Measures - Coefficient of Variance (CV).

Unit II –Basic Probability

Introduction, random experiments, sample space, events – Types of events - Definitions of Probability – classical, statistical and axiomatic - Conditional Probability - Addition and Multiplication theorem of probability - Bayes' theorem – simple problems.

Unit-III: Random variables and its implications

Random Variables: Discrete and continuous random variables, Probability mass function, Probability density function, Cumulative distribution function their properties. Expectation, variance, moments and moment generating function- simple problems.

Unit IV: Discrete and Continuous Distributions

Discrete probability distributions: Binomial, Poisson, Geometric,– properties and applications. Continuous Probability distributions: Uniform, Normal, Exponential, Beta, Gamma - properties and applications-simple problems.

Unit V- Correlation and Regression

Bivariate data: Definition, scatter diagram, simple correlation, rank correlation. Trivariate Data: Partial and Multiple correlation coefficients. Regression, regression coefficient, Estimation using the Regression Line, Fitting of linear and quadratic regression using principle of least squares-simple problems.

Books for study:

1. Sheldon M. Ross: Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, Elsevier (2014).
2. Gupta,S.C. and Kapoor, V.K. (2000): Fundamentals of Mathematical Statistics, 10/e, Sultan Chand and sons.
3. Gupta. S.P 'Statistical Methods' Sultan Chand & Sons, ^{48h} Edition, 2022.
4. Hooda, R. P. Statistics for business and economics. Vikas Publishing House, 2013.
5. Anderson D R, Sweeney D J and Williams T A: Statistics for Business and Economics, Thomson Publisher, 2005.
6. Levin. Richard. I and Rubin. David. S 'Statistics for Management' Prentice-Hall, 8th Edition. 2017.