PONDICHERRY UNIVERSITY

SYLLABUS FOR

B.Sc. (Honors) STATISTICS

Effective from the Academic Year 2024-2025

AFFILIATED COLLEGES

PREAMBLE
PONDICHERRY UNIVERSITY
HONORS DEGREE COURSE
REVISED SYLLABUS

B.Sc. (Honors or Honors by Research work) STATISTICS DEGREE COURSE

The revised syllabus shall be effective from the academic year **2024-2025 onwards.**

DURATION OF THE COURSE

The Curriculum Framework developed by the UGC for the implementation of NEP 2020 mandates that all Undergraduate (UG) degree programs, spanning 3 or 4 years, will lead to the award of UG or UG (Honours) degrees.

AGE LIMIT

The rules as applicable to other Under Graduate courses as prevailing in Pondicherry University.

ELIGIBILITY FOR ADMISSION

1. Candidates seeking admission to the first year of the B.Sc. (Honours) Statistics degree must have **passed the Higher Secondary course with at least 40% marks in Mathematics or Statistics** as one of the subjects, as conducted by the Government of Tamil Nadu or an equivalent system recognized by the Government of Puducherry. Eligibility will be determined based on the admission criteria prescribed by Pondicherry University.

2. **LATERAL ENTRY**

As per the National Education Policy (NEP-2020), students are provided with flexible entry options into the Programme of Study. The University Grants Commission (UGC) permits up to 10% of seats, over and above the sanctioned intake, to be reserved for lateral entry students. The guidelines for lateral entry into the B.Sc.(Honors) Statistics programme are as follows:

1. Lateral Entry into Second Year B.Sc. (Honors) Statistics:

Candidates must have completed a UG Certificate Course with a major in **Statistics or Mathematics** and a minor in **Mathematics or Statistics**, from a recognized university.

2. Lateral Entry into Third Year B.Sc. (Honors) Statistics:

Candidates must have completed a **UG Diploma Course in Statistics** with a minor in **Mathematics**, from a recognized university.

3. a). Lateral Entry into Third Year B.Sc. (Honors) Statistics:

Candidates must have completed a **UG Degree Course in Statistics** with a minor in **Mathematics**, from a recognized university.

b). Lateral Entry into Third Year B.Sc. (Honors by Research work) Statistics:

Candidates must have completed a **UG Degree Course in Statistics** with a minor in **Mathematics** from a recognized university and secured a CGPA of 7.5 or above in the first six semesters.

COURSE STRUCTURE

All Academic Programmes offered under NEP shall be stylized in terms of credits. Each course/subject in a given Programme of study shall carry certain number of credits which will be awarded on completion of the said course.

Exit Options and Qualifications under NEP 2020

As per the National Education Policy (NEP) 2020, undergraduate (UG) programs offer flexible exit options at the end of each academic year. Based on the number of credits earned and completion of specific requirements, students will be awarded the following qualifications:

1. **UG Certificate in Statistics**:

Awarded to students who choose to exit after the **first year**, provided they have earned a **minimum of 42 credits** and have completed a **work-based vocational course or internship worth 4 credits** during the **summer vacation** following the first year.

2. **UG Diploma in Statistics**:

Awarded to students exiting after the **second year**, upon earning a **minimum of 84 credits**, along with successful completion of a **4-credit work-based vocational course or internship** during the **summer vacation** after the second year.

3. **UG Degree in B.Sc. Statistics**:

Awarded to students who complete **three years** of study and have earned a **minimum of 124 credits**.

4. **UG Degree in B.Sc.(Honors) Statistics**:

Awarded to students who complete **four years** of study and have earned a **minimum of 164 credits**.

5. **UG Degree in B.Sc.(Honors by Research work) Statistics**:

Awarded to students who complete **four years** of study **with Research work** and have earned a **minimum of 164 credits**.

MEDIUM OF INSTRUCTION

The medium of instruction for B.Sc. (Honors) Statistics course, **shall be English**.

EVALUATION: Total Marks: 100

All Credit courses are evaluated for 100 marks. Internal Assessment component is for 25 marks and the End SemesterUniversity exam is for 75 marks. In case of Practicals, Project worketc., it is 50:50 marks for Internal and End-Semester Exams.

Break up of Internal Assessment Marks:

Total Internal Assessment mark for a theory subject is 25 marks.The breakup is:

a)	Mid Semester Exam (one) - 20 Marks
b)	Percentage of Attendance - 5 Marks
	Total - 25 Marks

Marks for Attendance is as follows:

Below 75%	75% - 80%	80% - 85%	85% - 90%	90% - 95%	95% - 100%
0	1	2	3	4	5

Internal Test Scheme:

Principal of the College schedules the Mid-Semester Exam for all courses during 8/9th week of the start of classes. All faculty members are expected to conduct this Mid-Semester exam for 1.30 hours duration and evaluate, upload the marks to the Controller of Examinations of the University. Colleges are also requested to preserve the answer books of Mid-Semester exams until declaration of results by the University

Internal Assessment marks for Practicals/Project work/Internships subjects:

Faculty member in-charge of Lab practicals shall evaluate the practical subjects for 50 marks. The break up is as follows:

a) Observation note/Demo note/Work dairy / etc.	20
b) Practical Record/Internship Report / etc.	30
Total	**50**

End-Semester University Exam:

Controller of Examinations (COE) of Pondicherry University schedules the End-Semester exams for all theory and practical subjects based on University calendar.

A detailed Exam Time Table shall be circulated to all Colleges at least 15 days before the start of exams mostly during 15/16th week of the Semester. Question Papers shall be set externally based on BOS approved syllabus. All students who have a minimum of 70% attendance are eligible to attend the end-semester exams. The breakup of end semester marks:

Theory subjects: (Sec A, Sec B and Sec C) Question from all units of syllabus	75 marks
Practical/Internship Project Work subjects (Based on Practical Exams/Presentation/Viva)	50 marks

Consolidation of Marks and passing Minimum

Controller of Examinations of the University consolidates the Internal Assessment marks uploaded by the Colleges and marks secured by students in end-semester examination. The total marks will be converted into letter grades. As per NEP Regulations, the passing minimum is 50% marks (IA + End semester put together) However, Pondicherry University considers 40% marks as pass during first 3 years of study and students who secured less than 50 will be awarded ‘P’ (Pass Grade)

Arrear Exam:

A student who failed to secure 40% marks in aggregate is declared as Failed and he is eligible to take up supplementary examination by registering to the said course in the following Semester. All other candidates who failed due to shortage of attendance, those who are seeking to improve the grade shall repeat the course.

Letter Grades and Calculation of CGPA:

Total Marks Secured by a student in each subject shall be converted into a letter grade. UGC Framework has suggested a Country wide uniform letter grades for all UG courses. The following Table shows the seven letter grades and corresponding meaning and the grade points for calculation of CGPA.

Marks	**Absent***	**< 40**	**40-49**	**50-55**	**56-60**	**61-65**	**66-70**	**71-79**	**80-100**
Letter Grade	AB	F	P	C	B	B+	A	A+	O
Grade Point	0	0	4	5	6	7	8	9	10

* (Lack of Attendance)

Calculation of Semester Grade Point average and CGPA:

Semester Grade Point Average (SGPA) is calculated by taking a weighted average of all grade points secured by a candidate from all subjects registered by him/her in the given Semester. The weights beingthe number of credits that each subject carries.

Cumulative Grade Point Average (CGPA) CGPA shall be calculated as the weighted average of credits that course carries and the value of Gradepoints averaged for all subjects.

Computation of SGPA and CGPA

The following procedure shall be followed to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

The SGPA is the ratio of the sum of the product of the number of credits withthe grade points scored by a student in all the courses taken by a student andthe sum of the number of credits of all the courses undergone by a student,

i.e. **SGPA** $(S_i) = \Sigma(C_i \times G_i) / \Sigma C_i$

Where C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

The CGPA shall also be calculated in a similar way of SGPA for all subjects taken by the students in all semesters.

Declaration of Results:

Controller of Examinations (COE) of the University shall declare the results of given UG programme following the CGPA secured by students by the end of 6^{th} Semester and 8^{th} Semester.

<u>PASS CLASSES</u>

Range of CGPA	**Result**
9.0 above	First Class with distinction
6.0 above	First Class
5.0 to 5.99	Second Class
4.0 to 4.99	Pass Class

Breakup of Credits and Courses:

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.

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.

SCHEME OF EXAMINATION (Theory Paper)

Total Marks: 100 (Internal: 25 & External: 75)

INTERNAL EXAMINATION: Maximum Marks: 25.

1. Mid-Semester Examination for 1.30 Hours duration shall be taken: 20 Marks
2. Attendance: 5 Marks

EXTERNAL EXAMINATION: Maximum Marks: 75.

1. Examinations shall be in three sections.
2. Section-A for 10 Marks, Section –B for 25 Marks and Section-C for 30 Marks.

Question Paper Pattern
SECTION – A: (5 x 2 = 10 Marks) 1. It is of short answer type. Each question carry 2 marks. 2. 10 questions to be given by setting 2 questions from each unit. **3.** Candidate should Answer all the questions.
SECTION – B: (5 x 5 = 25 Marks) 4. It is of descriptive answer type. Each question carry 5 marks. 5. 7 questions to be given by setting at least 1 question from each unit. **6.** Candidate should Answer 5 questions out of 7 questions.
SECTION – C: (3 x 10 = 30 Marks) 1. It is of essay answer type. Each question carry 10 Marks. **2.** 5 questions to be given by setting 1 question from each unit. **3.** Candidate should Answer 3 questions out of 5questions.

SCHEME OF EXAMINATION (Practical Paper)

Total Marks: 100: (Internal: 50 & External: 50)

INTERNAL EXAMINATION: Maximum Marks: 50

Components of Internal Evaluation

1. Attendance (5 Marks)
2. Observation Note book (5 Marks)
3. Model Practical Exam (40 Marks)

END-SEMESTER PRACTICAL EXAMINATION: Maximum marks: 50

Components of End-Semester Practical Evaluation

1. Practical Record (10 Marks)
2. University Practical Examination (40 Marks)

B.Sc., (Honors/Honors by Research work) Statistics
Course Structure for Affiliated Colleges from 2024-25 Onwards

SEMESTER I

Code No	Nature of Course	Title of the Course	Credits	Contact Hours
MJD 1	Major Disciplinary courses	MJD-1: Descriptive Statistics	4	5
MID 1	Minor Disciplinary Courses	MID-1: Mathematics for Statistics	4	5
MLD 1	Multi-Disciplinary courses	MLD-1: Choose anyone from MLD courses	3	4
AEC 1	Ability Enhancement courses	Tamil - 1/ Hindi -1/ French -1	3	4
SEC1	Skill Enhancement Course	SEC-1: Computational Statistics *	3	4
VAC	NEP Value added common courses I & II (Choose ANY TWO)	Environmental Education Understanding India (Theory/Field based) Health & Wellness/Yoga Education Digital Technology Education(Theory/Field based)	2 2	4 4
Total Credits/ Total Hours of Work			**21**	**30 Hours**

SEMESTER II

Code No	Nature of Course	Title of the Course	Credits	Contact Hours
MJD 2	Major Disciplinary courses	MJD-2: Probability Theory -I	4	5
MID 2	Minor Disciplinary courses	MID-2: Health and Vital Statistics	4	5
MLD 2	Multi-Disciplinary courses	MLD-2: Choose anyone from MLD courses	3	4
AEC 2	Ability Enhancement courses	English -1	3	4
SEC 2	Skill Enhancement Course	SEC-2: Introduction to Ms-Excel *	3	4
VAC	NEP Value added common courses III & IV (Choose TWO which is not offered in Semester I)	Environmental Education Understanding India (Theory/Field based) Health & Wellness/Yoga Education Digital Technology Education (Theory/Field based)	2 2	4 4
Total Credits/ Total Hours of Work			**21**	**30 Hours**

* Practical Paper which is offered by batch-wise classes (If student strength exceeds 25)

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 have to complete work based vocational course/internship of 4 credits during the summer vacation of the first year

SEMESTER III

Code No	Nature of Course	Title of the Course	Credits	Contact Hours
MJD 3 MJD 4	Major Disciplinary courses	MJD 3: Distribution Theory - I MJD 4: Sampling Theory - I	4 4	5 5
MID 3	Minor Disciplinary courses	MID-3: Real Analysis	4	5
MLD3	Multi-Disciplinary courses	MLD-3: Choose anyone from the MLD course	3	4
AEC 3	Ability Enhancement courses	Tamil -2 / Hindi -2 / French -2	3	4
SEC 3	Skill Enhancement Course	SEC-3: Statistical Computing with C++ *	3	6
Total Credits/ Total Hours of Work			**21**	**29 Hours**

SEMESTER IV

Code No	Nature of Course	Title of the Course	Credits	Contact Hours
MJD 5 MJD 6 MJD 7	Major Disciplinary courses	MJD 5 Estimation Theory MJD 6 Applied Statistics MJD 7 Statistics Practical– I * (Sampling Theory, Estimation Theory & Applied Statistics)	4 4 4	5 5 8
MID 4	Minor Disciplinary courses	MID-4; Numerical Methods	4	5
AEC 4	Ability Enhancement courses	English- 2	3	4
Project	WP/Internship	Community Engagement	2	4
Total Credits/ Total Hours of Work			**21**	**31 Hours**

* Practical Paper which is offered by batch wise classes (If student strength exceeds 25)

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 have to complete work based vocational course/internship of 4 credits during the summer vacation of the Second year

SEMESTER V				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Contact Hours**
MJD 8 MJD 9 MJD 10	Major Disciplinary courses	MJD 8: Testing of Hypotheses MJD 9: Design of Experiments –I MJD 10: Regression Analysis	4 4 4	5 5 5
MID 5	Minor Disciplinary courses	MID-5: _Data Analysis using SPSS *	4	8
SKD	Skill Development Course	MJD 11: – Summer Internship #	4	6
		Total Credits/ Total Hours of Work	**20 Credit**	**29 Hours**

SEMESTER VI				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Contact Hours**
MJD 12 MJD 13 MJD 14 MJD 15	Major Disciplinary courses (compulsory)	MJD 12: Stochastic Processes MJD 13: Operations Research MJD 14: Statistical Quality Control MJD 15: Statistics Practical – II * (Testing of Hypotheses & Design of Experiments, Regression Analysis & Statistical Quality Control)	4 4 4 4	5 5 5 8
MID 6	Minor Disciplinary courses	MID-6: Statistical Analysis using R *	4	8
		Total Credits/ Total Hours of Work	**20 Credit**	**31 Hours**

* Practical Paper which is offered by batch-wise classes (If student strength exceeds 25)

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

SEMESTER VII				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Contact Hours**
MJD 16 MJD 17 MJD 18	Major Disciplinary courses	MJD 16: Probability Theory - II MJD 17: Distribution Theory - II MJD 18: Statistical Inference –I	4 4 4	5 5 5
MID 7	Minor Disciplinary course	MID-7: Sampling Theory - II	4	5
MID 8		MID-8: Statistical Analysis using Python*	4	8
		Total Credits/ Total Hours of Work	**20 Credit**	**28 Hours**

SEMESTER VIII B.Sc. (Honors) Statistics by Course Work				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Contact Hours**
MJD 19 MJD 20	Major Disciplinary courses	MJD 19: Multivariate Analysis MJD 20: Statistical Inference –II	4 4	5 5
MJD 21	Major Disciplinary courses	MJD 21: Design of Experiments - II	4	5
MJD 22		MJD 22: Statistics Practical – III* *(Statistical Inferences, Multivariate Analysis, Design of Experiments)*	4	8
MJD 23		Choose ANY ONE for MJD 23: Indian Official Statistical Systems Biostatistics Reliability Theory Queueing and inventory theory Statistical Data Mining Methods	4	5
		Total Credits/ Total Hours of Work	**20 Credit**	**28 Hours**

* Practical Paper which is offered by batch-wise classes (If student strength exceeds 25)

Students will be awarded **UG degree in B.Sc. (Honors) Statistics by Course Work** after successful completion of four years, provided they have earned a minimum of 164 credits

Students who secure a minimum of 7.5 CGPA in the semesters I to VI and wish to undertake research at the UG level can choose **B.Sc. (Honors) Statistics by Research** stream. The research work / Dissertation should be in the major discipline and under the guidance of a faculty member of the department.

SEMESTER VIII B.Sc. (Honors) Statistics by Research work				
Code No	**Nature of Course**	**Title of the Course**	**Credits**	**Contact Hours**
MJD 19 MJD 20	Major Disciplinary courses	MJD 19: Multivariate Analysis MJD 20: Statistical Inference - II	4 4	5 5
RP/D	Research Work	**Research Project / Dissertation** Choose ANY ONE MAJOR discipline in this course as a field of Research work according to the faculty member's area of specialization.	12	20^{+}
		Total Credits/ Total Hours of Work	**20 Credit**	**30 Hours**

+ if five faculty members in the department, they may share the workload of 4 hours each (5x4=20hours)

Students will be awarded **UG degree in B.Sc. (Honors) Statistics by Research** after successful completion of four years, provided they have earned a minimum of 164 credits with research work.

Choose ANY ONE Multidisciplinary (MLD) Course to offer in the Semester I, II and III

Natural Sciences: 1) Herbal Nutrition, 2) Basic Botany, 3) Basic Zoology, 4) Basic Microbiology, 5) Fundamentals of Biotechnology
Physical Sciences: 1) Electronics in Everyday Life, 2) Chemistry in Everyday Life, 3) Science and Society, 4) Energy in Everyday Life, 5) Basic Mathematics
Humanities/Social Sciences: 1) Basic Economics Concepts and Measurement, 2) Basics of Accounting, 3) French for Beginners, 4) Commercial Geography, 5) Introduction to Public Administration

Course Code	MJD-1	DESCRIPTIVE STATISTICS	L	T	P	Credits
Core	**MAJOR**	**Semester I**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge of Mathematics				

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 – Primary and Secondary data –Types of data: Nominal, Ordinal, Ratio, and Interval scale (with examples) - Graphical Representation of data – Bar-charts, Pie-diagrams, Histograms, Frequency polygon, Ogives
Unit:2
Measures of central tendency – properties – merits and demerits – mean, weighted mean –median, quartiles, deciles, percentiles and mode – relation between arithmetic mean, geometric mean and harmonic mean.
Unit:3
Measures of dispersion –Range, Quartile Deviation, Mean Deviation and Standard Deviation- – Coefficient of variation – Moments –central moments in terms of raw moments and moments about arbitrary points
Unit:4
Skewness and Kurtosis – Pearson’s coefficient of skewness – Bowley’s coefficient of skewness – coefficient of skewness based upon moments
Unit:5
Simple correlation – Meaning, Types of Correlation, Karl Pearson’s coefficient of correlation – Rank correlation (with and without ties)– Multiple and Partial correlation coefficient (three variables only) – Simple Regression – Properties.

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	MID-1	MATHEMATICS FOR STATISTICS	L	T	P	Credits
Core	**MINOR**	**Semester I**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Mathematics (higher secondary level)				

Course Objectives

- To understand the derivatives of functions
- 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

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

Successive Differentiation – Leibnitz Theorem – 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

Unit:5

Laplace Transform: Introduction - definition - properties - Laplace transforms of standard 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.

Reference Books

1	T.K. Manicavachagom Pillay, T. Natarajan, K.S. Gnanapathy (1999), Algebra, Volume II, S. Viswanathan Printers & Publishers Pvt.Ltd., Chennai.
2	T.K. Manicavachagom Pillay, T. Natarajan, K.S. Gnanapathy, Calculus, Vol I, II & III, S. Viswanathan Printers & Publishers Pvt.Ltd., Chennai.
3	B.S. Grewal (2014): Higher Engineering Mathematics, Khanna Publishers.

Course Code	SEC-1	COMPUTATIONAL STATISTICS	L	T	P	Credits
Core	**SEC**	**Semester I**	**-**	**-**	**4**	**3**
Pre-requisite		Arithmetic Skill				
Diagrammatic Representation: Simple Bar Chart, Subdivided Bar Chart, Multiple Bar Chart, Pie Diagram						
Construction of Discrete and Continuous Frequency Tables from Raw Data						
Graphical Representation – Histogram, frequency polygon, Ogives						
Two-way tables and Scatter plots						
Measures of Central Tendency (for Raw, Discrete and Continuous Data)						
Measures of Dispersion (for Raw, Discrete and Continuous Data)						
Skewness and kurtosis						
Simple correlation						
Rank correlation (repeated rank)						
Simple Regression						

Evaluation Methodology:

Break up Marks (Internal: **50**; End-Semester: **50**)

1. Components of Internal Evaluation (50 Marks)

   Attendance
   Observation Notebook
   Model Practical Exam
2. Components of End-Semester Exams (50 Marks)
   Practical Record
   Answer ANY FOUR out of six questions

Course Code	MJD-2	PROBABILITY THEORY-I	L	T	P	Credits
Core	**MAJOR**	**Semester II**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Mathematics				
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						
Introduction to probability theory – Random experiments, Events, Sample space, Algebra of events, Operations on events – Classical approach to probability – Mathematical and Statistical Probability - Axiomatic approach to probability – Simple problems						
Unit:2						
Addition theorem - Conditional Probability – Independence of events – Multiplication theorem – Bayes theorem – Simple problems.						
Unit:3						
Random variables – Discrete and Continuous Random Variable – Probability Mass function and Probability Density function – Distribution function – Properties – Simple problems						
Unit:4						
Mathematical Expectation of random variables and its properties - Moment generating function– Cumulant generating function – Characteristic function – Definition - their properties for discrete and continuous variates – Simple problems						
Unit:5						
Chebyshev's inequality - Definition of convergence in probability and distributions - 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	A. M. Mood, F. A. Graybill, D. C. Boes (2002), Introductory to the Theory of Statistics, 3/e, Mc Graw hill
3	Gupta, S.C. and Kapoor, V.K.(2000):Fundamentals of Mathematical Statistics, 10/e, Sultan Chand and Sons.

Reference Books

1	Bansilal and Sanjay Arora (2002): New Mathematical Statistics, Satyaprakashan Publications, New Delhi.
2	Rohatgi V.K. and Md. Ehsanes Saleh A.K.(2001): An Introduction to Probability and Statistics, Second Edition, John Wiley Publication.
3	Bhat B.R, Srivenkataramana T and Rao Madhava K.S(1996): Statistics: A Beginner's Text, Vol.II, New Age International(P) Ltd.
4	Murray R. Spiegel, John J. Schiller, R. Alu Srinivasan (2013), Schaum's Outline of Probability and Statistics, Fourth Edition, The McGraw-Hill Companies, Inc.

Course Code	MID-2	HEALTH AND VITAL STATISTICS	L	T	P	Credits
Core	**MINOR**	**Semester II**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Basic Statistics				

Course Objectives

The objective for this course is to learn the theory and methods of Mortality and Fertility rates are arrived at using vital statistics. Population projection is made by different methods

Expected Course Outcomes

1. A student will be able to understand the mortality and fertility rates
2. To construct the life table using Vital statistics

Unit:1

Health statistics: Introduction, utilization of basic data - sources of health statistics - problems in the collection of sickness data - measurement of sickness, -hospital statistics and the international classification of diseases - sources of demographic data in India: census, vital events, registration, survey, extent of under registration

Unit:2

Measures of mortality - Crude and specific rates - infant mortality rate - direct and indirect standardization of death rates - complete life table structure - interrelationship among life functions uses of life table

Unit:3

Measures of fertility – CBR, ASBR, GFR and TFR - cohort fertility analysis measures of migration - crude, specific and standardized rates - survival ratio - National growth rate method

Unit:4

Forces of mortality - Gompertz and Makeham law - Abridged life table - Construction by Reed Merril King and Graville methods

Unit:5

Population growth and change - Arithmetic, geometric and exponential growth rates - population estimation and projection – GRR, NRR component method of projection - logistic curve

Total Lecture Hours	**60 Hours**

Books for Study

1	Parimal Mukhopadhyay (2011), Applied Statistics, Books & Allied (P) Ltd
2	Bhaskar.D.Misra (1982): An introduction to the study of population, South Asian Publishers Pvt. Ltd

Reference Books

1	Barclay.G.W. (1958): Techniques of population Analysis, John Wily, New York
2	Keyfitz.N. (2005): Applied Mathematical Demography, John Wiley, New York

Course Code	SEC-2	INTRODUCTION TO MS-EXCEL*	L	T	P	Credits
Core	**SEC**	**Semester II**	**-**	**-**	**4**	**3**
Pre-requisite		Knowledge in computer basics				
Course Objectives						
The objective for this course is to learn the time-saving techniques/ shortcuts to work more efficiently statistical analysis in Excel.						
Expected Course Outcomes						
To acquire proficient in using Microsoft Excel, including understanding the interface, menus, and basic navigation To develop the ability to perform various data analysis tasks, such as sorting, filtering, and conditional formatting						
Unit:1						
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						
One dimensional, two dimensional data presentation – Histogram, line diagram – Box plots – Scatter plots. Bar charts – stack, subdivided, pie charts, radar graphs						
Unit:3						
Arithmetic Mean, Median, Mode, Geometric mean and Harmonic mean, Range, Quartile Deviation						
Unit:4						
Mean Deviation, Standard Deviation, Coefficient of Variation. Central and Non-Central moments and their interrelationship. Sheppard's correction for moments. Skewness and kurtosis						
Unit:5						
Simple Correlation – Correlation graph, Rank Correlation, Simple Regression - Matrix Operations – Addition, multiplication, subtraction, inverse and transpose						
Total Lecture Hours						**60 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					

Practical Exercises: The Instructor or faculty incharge of the course will select and assign the practical exercise based on the syllabus

Evaluation Methodology: Break up Marks (Internal:**50**; End-Semester:**50**)

Components of Internal Evaluation (50 Marks)

- Attendance
- Observation Notebook
- Model Practical Exam

End-Semester Practical Exams (50 Marks)

- Practical Record
- Practical Exam

Course Code	MJD-3	DISTRIBUTION THEORY - I	L	T	P	Credits
Core	**MAJOR**	**Semester III**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in probability and mathematics				
Course Objectives						
The objective for this course is to learn the discrete and continuous probability distribution problems, working with real-time problems and understanding how distribution functions can be used in various contexts, will help students to become proficient in applying these skills in their academics.						
Expected Course Outcomes						
A student will be able to: Gain expertise in deriving and working with PDFs for continuous distributions and PMFs for discrete distributions. Understand their properties and how to use them to calculate probabilities and moments.						
Unit:1						
Concept of univariate and bivariate distributions – discrete and continuous type – joint density function – marginal density function – conditional distribution function and conditional density function – marginal and conditional expectation.						
Unit:2						
Discrete Distributions – Uniform, Bernoulli, Binomial, Poisson, Negative Binomial, Geometric distribution and their characteristics.						
Unit:3						
Continuous distributions - Uniform, Normal, Exponential, Gamma, Beta, Cauchy Distributions – Characteristics - Properties of these distributions						
Unit:4						
Sampling Distributions – t, F and Chi-square – derivation of their probability density functions -properties of t, F and chi-square – relation among t, F and chi-square distributions						
Unit:5						
Order Statistics – Distribution of minimum, maximum and r^{th} order statistics – joint distribution of r^{th} and s^{th} order statistics – distribution of range and mid-range.						
		Total Lecture Hours				**60 Hours**

Books for Study	
1	Gupta, S. C and Kapoor, V.K (2010), Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
2	Murray R. Spiegel, John J. Schiller, R. Alu Srinivasan (2013), Schaum's Outline of Probability and Statistics, Fourth Edition, The McGraw-Hill Companies, Inc.
3	Rohatgi V.K. and Md. Ehsanes Saleh A.K.(2001): An Introduction to Probability and Statistics, Second Edition, John Wiley Publication
Reference Books	
1	Hogg R.V. and Craig A.T. (1998): Introduction to Mathematical Statistics, 4th edition, Collier Macmillan Press.
2	Bhat B.R, Srivenkataramana T and Rao Madhava K.S.(1996): Statistics: A Beginner's Text, Vol. II, New Age International(P) Ltd.
3	Mood A.M., Graybill F.A and Boes D.C. (2002): Introduction to the theory of statistics, McGraw Hill.

Course Code	MJD-3	SAMPLING THEORY – I	L	T	P	Credits
Core	**MAJOR**	**Semester III**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Elements of Probability Theory and Probability Distributions				
Course Objectives						
The objective for this course is to learn the Understanding Sampling Concepts, Probability and Non-Probability Sampling, Sampling Frame, Survey Design and Questionnaire Construction and Data Collection Techniques.						
Expected Course Outcomes						
A student will be able to: Understand the key terms and concepts related to sampling Techniques, such as random sampling, stratified sampling, Systematic Sampling and cluster sampling						
Unit:1						
Concept of sampling – 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: Proportional, Optimum and Neyman – estimation of gain due to stratification						
Unit:4						
Systematic Sampling – Estimation of population mean and its sampling variance – comparison of systematic, simple random and stratified random sampling.						
Unit:5						
Cluster sampling with equal-sized clusters – estimation of population mean and variance - comparison of cluster and random sampling, Comparison of systematic, simple random and stratified.						
		Total Lecture Hours	**60 Hours**			

Books for Study	
1	Daroga Singh and F.S.Choudhary (1986), Theory and analysis of Sample Survey Designs, Wiley Eastern Ltd.
2	S.C. Gupta and V.K.Kapoor (2007), Fundamentals of Applied Statistics, Sultan Chand and Sons.
Reference Books	
1	W.G.Cochran(1999), Sampling Techniques, 3rd Edition, Wiley Eastern Ltd.
2	Pandurang.V.Sukhatme and Balkrishna.V.Sukhatme(1970): Sampling Theory of Survey with application, Asia Publication House.
3	ParimalMukhopadhyay (2008): Theory and Methods of Survey Sampling, Prentice Hall of India

Course Code	MID-3	REAL ANALYSIS	L	T	P	Credits
Core	**MINOR**	**Semester III**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in mathematics				

Course Objectives

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

Expected Course Outcomes

A student will be able to: 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

Unit:4

Increasing and Decreasing functions – Differentiability – Darboux's Theorm – Rolle's Theorem – Mean value theorem for derivatives – Taylor's Series expansion

Unit:5

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	D. Somasundaram and B. Choudhary (2002) : A first course in Mathematical Analysis, Narosa Publishing House
2	R. R. Goldberg (1970) : Methods of Real Analysis, Oxford & IBH.

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.
3	Malik S.C. and Savita Arora (2010): Mathematical Analysis, 4/e, New Age International

Course Code	SEC-3	STATISTICAL COMPUTING WITH C++ (Practical)*	L	T	P	Credits
Core	**SEC**	**Semester III**	**--**	**--**	**6**	**3**
Pre-requisite		Knowledge on logical thinking and Problem-solving skills				

Course Objectives

The main objectives of this course are:

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

Expected Course Outcomes

A student will be able to:

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

Unit:1

Introduction to C++ - Applications of C++ - Structure of a Simple C++ Program – Compiling and Executing C++ programs. Keywords – Identifiers – Constants – Basic Data Types – Variable declaration – Operators - Precedence – Array Handling

Unit:2

Introduction to Functions – Library Functions - Steps in writing user defined functions – Inline Functions – Recursion – Default parameters – Call by value – Call by reference

Unit:3

Object oriented programming paradigm – Basic OOP concepts – Benefits – Object Oriented Programming languages – Applications – Class definition – Member functions – Static members – Constructor and destructors: various types

Unit:4

Operator overloading: Unary , binary – Rules for Operator overloading – Type conversions - Function overloading – Friend and Virtual Functions. Inheritance : Various Types , Applications – Abstract classes – Virtual base classes

Unit:5

Introduction to Streams - Formatted IO – Unformatted IO. Files in C++ : Introduction, various operations, modes – Sequential and random files – Error handling in File operations – Command-line arguments

Total Lecture Hours	**60 Hours**

Books for Study

1	E.Balagurusamy (2013): Object Oriented Programming With C++, McGraw-Hill Education, Sixth Edition.

Reference Books

1	Herbert Schildt (2017): C++ The Complete Reference, McGraw Hill Education, Fourth Edition.

Practical Exercises: The Instructor or faculty incharge of the course will select and assign the practical exercise based on the syllabus

Evaluation Methodology: Break up Marks (Internal:**50**; End-Semester:**50**)

Components of Internal Evaluation (50 Marks)

Attendance, Observation Notebook, Model Practical Exam

End-Semester Practical Exams (50 Marks)

Practical Record, Practical Exam

Course Code	MJD-5	ESTIMATION THEORY	L	T	P	Credits
Core	MAJOR	Semester IV	4	1	-	4
Pre-requisite		Knowledge in probability and distribution theory				

Course Objectives

This course focuses on point and interval estimation techniques.

Expected Course Outcomes

A student will be able to:

1. Study the different methods of point estimation
2. Construct confidence intervals for population parameters

Unit:1

Point estimation – Properties of estimators – Unbiasedness –Consistent estimators - Properties of consistent estimators – sufficient condition for consistency – Simple problems

Unit:2

Concept of efficiency – Minimum Variance Unbiased Estimator (MVUE) – Cramer-Rao inequality - Simple Problems – Concept of Sufficient statistics with illustration – Neyman Factorization theorem discrete case with proof–Concept of UMVUE - Rao-Blackwell theorem - Simple problems.

Unit:3

Method of Maximum Likelihood (M.L.E.) – Properties of Maximum Likelihood Estimators (without proof) - Method of Minimum Chi-square –Simple Problems

Unit:4

Methods of moments – Method of Least Squares —Properties - Simple problems

Unit:5

Interval Estimation - Concepts of Confidence Interval and Confidence Coefficient –Exact Confidence Intervals for mean, difference of means, variance, ratio of variance of two independent normal populations - Proportions (single and difference) – Large sample confidence interval.

Total Lecture Hours	60 Hours

Books for Study

1	Rohatgi V.K. and Md. EhsanesSalehA.K.(2001): An Introduction to Probability and Statistics, Second Edition, John Wiley Publication
2	Gupta, S. C and Kapoor, V.K (2010), Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

Reference Books

1	Hogg R.V., Craig A.T. and Joseph W Mckean(2005): Introduction to Mathematical Statistics, 6^{th} edition,
2	Mood A.M., Graybill F.A and Boes D.C. (1974): Introduction to Theory of Statistics, McGraw Hill.
3	Kale, B.K, Muralidharan, K, (2015), Parametric Inference: An introduction, Alpha Science International Ltd.

Course Code	MJD-6	APPLIED STATISTICS	L	T	P	Credits
Core	**MAJOR**	**Semester IV**	**4**	**1**	**-**	**4**
Pre-requisite		Basic Statistics				

Course Objectives

The main objectives of this course are:

1. The varieties of index numbers are highlighted.
2. The mathematical models for time series data, such as supply and demand analysis

Expected Course Outcomes

A student will be able to:

1. To formulate linear and non-linear models for Time series data and give projections for future.
2. To understand the basic problems in the construction of index numbers and various types of index numbers.
3. To analyze the demand and supply of various products with respect to their elasticity

Unit:1

Concept of time series - components of a time series - Additive and Multiplicative models - Resolving the components of a time series - Evaluation of trend by least square method- straight line, quadratic, exponential and logistic curve - Methods of moving averages

Unit:2

Seasonal Variations – Measurement of seasonal variations: Method of Simple average - Ratio to moving average - Ratio to trend - Link relative method - Cyclical fluctuations - Random component in time series - Variate difference method

Unit:3

Index numbers – Definitions and uses –simple and weighted aggregates procedures, Index numbers -Laspeyre's, Paasche's, Fisher's, Marshall Edgeworth index numbers – Fixed and Chain base index numbers.

Unit:4

Optimum tests for index numbers - Cost of living index number - Construction and uses of wholesale price index

Unit:5

Demand Analysis – demand and supply, price elasticities of supply and demand, partial and cross elasticities of demand, methods of determining demand and supply curves- Leontief's method of finding demand curve from time series data, Pigous's method- Engel curves- first method, second method – Pareto's law of income distribution.

Total Lecture Hours	**60 Hours**

Books for Study

1	Kapoor V.K. and Gupta S.C. (1978): Fundamentals of Applied Statistics, Sultan Chand ans Sons.
2	Mukhopadhyay P. (1999): Applied Statistics, New Central Book Agency Pvt.Ltd., Calcutta.
3	Saluja M.R. (1972): Indian official Statistical Systems, Statistical Publishing Society, Calcutta and The Indian Econometric Society, Hyderabad

Reference Books

1	Croxton F.E, Cowden D.J and Kelin S (1973): Applied General Statistics, Prentice Hall of India.
2	Guide to current Indian Official Statistics. Central Statistical Organization, Govt. of India
3	Goon A.M, Gupta M.K., Das Gupta B. (1991): Fundamentals of Statistics, Vol. II, World Press, Calcutta.

Course Code	MJD - 7	STATISTICS PRACTICAL - I	L	T	P	Credits
Core	**MAJOR**	**Semester IV**	**-**	**-**	**8**	**4**
Pre-requisite						

ESTIMATION THEORY
Estimation of the parameters for the discrete and continuous distribution by the Method of Moments
Estimation of the parameters for the discrete and continuous distribution by the Method of Maximum Likelihood
Confidence Intervals for the parameters of Normal distribution Single Mean
Confidence Intervals for the parameters of Normal distribution Two Population Means
Confidence Intervals for the parameters of Normal distribution Single Variance
Confidence Intervals for the parameters of Normal distribution Two Population Variances
Confidence Interval for Single Proportion and Two Proportions
APPLIED STATISTICS
Time series: Curve fitting by principle of least squares - Straight line, Quadratic, Exponential and Logistic curves
Seasonal fluctuations: Ratio to trend method, Ratio to moving average method and Link relative method
Index numbers: Calculation of indices using Laspeyre's, Paasche's, Marshall-Edgeworth, Bowley's and Fisher's formula, Time reversal test and factor reversal test
SAMPLING THEORY
Simple Random Sampling with replacement
Simple Random Sampling without replacement
Stratified Sampling -proportional allocation
Stratified Sampling - optimum allocation
Systematic Sampling

Evaluation Methodology:

Break up Marks (Internal:**50**; End-Semester:**50**)

Components of Internal Evaluation (50 Marks)

Attendance
Observation Notebook
Model Practical Exam

Components of End-Semester Exams (50 Marks)

Practical Record
Practical Exam

Course Code	MID-4	NUMERICAL METHODS	L	T	P	Credits
Core	**MINOR**	**Semester IV**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge on Basics of Calculus				

Course Objectives
To learn the solution of Algebraic and transcendental equations, Finite differences, interpolation techniques
Expected Course Outcomes
A student will be able to: gain sufficient knowledge in using interpolation techniques for finding roots of polynomial equations and evaluating integrals of functions.
Unit:1
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
Forward and backward differences – Differences of a polynomial – Relation between the Operators E, Δ, δ, μ and backward difference operator, and their basic properties – Application to summation of series
Unit:3
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 Divided differences and their properties – Newton's divided difference formula – Lagrange's formula – simple problems only.
Unit:4
Iteration or successive approximation method – Lagrange's method — simple problems Trapezoidal rule – Simpson's 1/3 and 3/8 rules – Weddle's rule – Euler's summation formula
Unit:5
Introduction - Definitions - Formation of difference equations- Linear difference equations – Rules for finding the complementary function – Rules for finding the particular integral – Difference equations reducible to linear form – Simultaneous difference equations with constant coefficients
Total Lecture Hours — **60 Hours**

Books for Study	
1	S.S.Sastry (1998): Introductory Methods of Numerical Analysis, Prentice-Hall of India.
2	M. K. Venkatraman (2008): Numerical Methods in Engineering and Science, National Publishing company, India
Reference Books	
1	Scarborough B (2005): Numerical Mathematical Analysis, Oxford University Press.
2	B. S. Grewal(1997): Numerical Methods in Engineering and Science, Khanna Publishers, India

Title of the subject : **COMMUNITY ENGANEMENT**

Course code : **Project WP/Internship**

Community Engagement:

The Community Engagement Learning Project is a short course that provides students with the opportunity to engage with a not-for-profit or government organization by undertaking a group project identified by the organization.

Students will explore the concept of community engagement, the role of the community sector in nearby area, the context in which the sector operates, and the tools the sector has available to it to deliver services, influence policy and programs, and provide information to its client groups.

Students will have the opportunity to develop a range of skills through the seminar program as well as engaging with a local organization that delivers services to the community.

Guidelines for the course

1. A Community Engagement course shall be assessed for a maximum of 100 marks. The assessment may be based on the report, presentation, and viva-voce.
2. A Community Engagement course may be undertaken by a group of students. However, the Community Engagement course report shall be submitted by each member of the team separately.
3. A Community Engagement course shall be supervised by a faculty member assigned by the Head of the Department.
4. There shall be an internal examiner for the evaluation of the Community Engagement course.
5. A Community Engagement course should encourage a student to be able to interact with the end user.
6. A Community Engagement course should be chosen such that there is enough scope to apply and demonstrate the subjects learnt in the course.

SCHEME OF EXAMINATION - Total Marks: 100

Internal marks (based on Internship report, work dairy, etc.): 50 marks

External marks (based on presentation, viva-voce, etc.): 50 marks

Course Code	MJD -8	TESTING OF HYPOTHESES	L	T	P	Credits
Core	**MAJOR**	**Semester V**	**4**	**1**	**-**	**4**
Pre-requisite		Theory of Estimation and Distribution Theory				

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

A 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

Statistical Hypothesis – Simple and composite hypothesis, Null and Alternative Hypothesis – Two types of errors – Critical region – p-value – Power of test – Most powerful test – Neymann Pearson Lemma – Simple problems.

Unit:2

Monotone Likelihood Ratio Property – Examples - Uniformly most powerful tests – definition – UMP test for one parameter exponential family and simple applications.

Unit:3

Likelihood Ratio tests – Definition and properties - simple applications- Test of significance: Exact and Asymptotic test based on Normal distribution.

Unit:4

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. Median Chi-square test for goodness of fit and test for independence of attributes. Tests based on Student's t, Chi-square and F-distributions, Chi-square test for goodness of fit and independence of attributes.

Unit:5

Non-parametric methods: Sign test – Wilcoxon Signed rank test- Mann Whitney U test - Median test - Run test – Kolmogrov-Smirnov test for one sample and two samples

Total Lecture Hours	**60 Hours**

Books for Study

1	Gupta, S. C and Kapoor, V.K (2010), Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi
2	Goon A.M, Gupta M.K., Das Gupta B. (1991): Fundamentals of Statistics, Vol. II, World Press, Calcutta.

Reference Books

1	Kale, B.K, Muralidharan, K, (2015), Parametric Inference: An introduction, Alpha Science International Ltd.
2	Manoj Kumar Srivastava, Namita Srivastava(2009) Statistical Inference: Testing of Hypotheses), PHI, New Delhi
3	Hogg R.V., Craig A.T. and Joseph W Mckean (2005): Introduction to Mathematical Statistics, 6^{th} edition

Course Code	MJD - 9	DESIGN OF EXPERIMENTS - I	L	T	P	Credits
Core	MAJOR	Semester V	4	1	-	4
Pre-requisite		Knowledge in Distribution Theory and Statistical Inference				

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

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

Basic principles for designing statistical experiments: Randomization, Replication and local control - Analysis of variance with One way – Two-way classification models and estimation of parameters

Unit:2

Completely Randomized Design (CRD) – Model - estimation of parameters and their standard error – Analysis of data arising from such design, multiple comparison test: Least Significant Difference, Tukey's test, Duncan's Multiple Range test (DMRT), Student Newman Keul Test (SNK)

Unit:3

Randomized Block Design (RBD) - Models and estimation of parameters - Estimation of one and two missing observations – Efficiency of RBD relative to CRD

Unit:4

Latin Square Design (LSD)– Model and estimation of parameters - Estimation of one and two missing observations – Efficiency of LSD relative to CRD and RBD

Unit:5

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

Total Lecture Hours	**60 Hours**

Books for Study

1	Gupta S.C.and Kapoor V.K. (2001): Fundamentals of Applied Statistics, Sultan Chand & Sons.
2	Montgomery D.C.(2010): Design and Analysis of Experiments, John Wiley.

Reference Books

1	Das.M.N and Giri.N.C (1986): Design and Analysis of Experiments, Wiley Eastern Limited.
2	W.T.Federer (1967): Experimental Design, Oxford & IBH Publishing Co.
3	Goon A.M, Gupta M.K., Das Gupta B. (1991): Fundamentals of Statistics, Vol. II, World Press, Calcutta

Course Code	MJD- 10	REGRESSION ANALYSIS	L	T	P	Credits
Core	MAJOR	Semester V	4	1	-	4
Pre-requisite		Statistical Inference				

Course Objectives

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

Expected Course Outcomes

A student will be able to:

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

Unit:1

Simple Regression model: Description of data model – lines of regression – Properties of regression coefficients – least square estimates -Index of fit – Predicted values and standard errors – Evaluation of fit – Analysis of residuals. Effect of outliers in simple linear regression – Model adequacy and residual plots – Deletion of data points

Unit:2

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:3

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:4

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:5

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, 5th Edition

Reference Books

1	Chatterjee, 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.

Course Code	MID -5	DATA ANALYSIS USING SPSS (Practical)*	L	T	P	Credits
Core	MINOR	Semester V	-	-	8	4
Pre-requisite		Basic knowledge in computer and Statistical tests				

Course Objectives		
The main objectives of this course are: To calculate and interpret descriptive statistics, Create basic charts and graphs to visualize data using SPSS, To calculate and interpret different statistical tools		
Expected Course Outcomes		
A student will be able to: To train with the Graphical and diagrammatic representation using SPSS To understand the analysis and interpretation of various statistical tools		
Unit:1		
Basic of SPSS – Importing and Exporting of files – value labels, Recoding and Computing new variables – visual binning - Selection of cases (simple and multiple selection) – splitting and merging of files		
Unit:2		
Graphical plots: Box Plot both simple and multiple, Scatter plot – 2D and 3D, Histogram both simple and paneled by rows and columns using categorical variables, Bar and Pie charts, Frequencies, Custom tables – two way and multi way, Cross Tabulations		
Unit:3		
Fitting of Curves: Parabola, cubic and exponential – correlation and regression: simple, multiple – Rank correlation – test for intercept and slope – variable selection: forward, backward and stepwise		
Unit:4		
Testing of Hypotheses – one sample, two sample and paired samples t – test; F-test for two sample variances; Chi-square test for independence of attributes, Sign Test, Mann-Whitney U test, Wilcoxon-Sign rank test, Median test		
Unit:5		
CRD, RBD, LSD, 2^2 and 2^3 factorial designs, Regression model		
	Total Lecture Hours	**60 Hours**

Books for Study	
1	Ajai S. Gaur and Sanjaya S Gaur (2009), **Statistical Methods for Practice and Research -** A Guide to Data Analysis Using SPSS, Second Edition, SAGE Publications Pvt. Ltd
2	Sarma KVS (2010), Statistics Made Simple – Do It Yourself on PC, Second Edition, PHI Learning
Reference Books	
1	Sabina Landau and Brian S. Everitt (2004), A Hand book of Statistical Analysis using SPSS, Chapman and Hall, CRC Press
3	Robert Ho (2006), Handbook of Univariate and Multivariate Data Analysis and Interpretation with SPSS, Chapman and Hall, CRC Press

Practical Exercises:

The Instructor or faculty incharge of the course will select and assign the practical exercise based on the syllabus

Evaluation methodology: (Practical)

Internal Assessment (Mid-Semester Exam) – 50 Marks

End-Semester University Exam – 50 Marks

Title of the subject : **SUMMER INTERNSHIP**

Course code : **MJD 11: SKD (Skill Development Course)**

Guidelines for the course

1. A Summer Internship course shall be assessed for a maximum of 100 marks. The assessment may be based on the report, presentation, and viva-voce.
2. A Summer Internship course may be undertaken by a group of students and the maximum number of students in a team shall not exceed five. However, the Summer Internship course report shall be submitted by each member of the team separately.
3. A Summer Internship course shall be supervised by a faculty member assigned by the Head of the Department.
4. There shall be an internal examiner for the evaluation of the Summer Internship course.
5. A Summer Internship course should encourage a student to be able to interact with the end user.
6. A Summer Internship course should be chosen such that there is enough scope to apply and demonstrate the subjects learnt in the course.

SCHEME OF EXAMINATION

Total Marks: 100

Internal marks (based on Internship report, work dairy, etc.): 50 marks

External marks (based on presentation, viva-voce, etc.): 50 marks

Course Code	MJD - 12	STOCHASTIC PROCESSES	L	T	P	Credits
Core	MAJOR	Semester VI	4	1	-	4
Pre-requisite		Knowledge in basic mathematics and probability				

Course Objectives

The main objectives of this course are:

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

Expected Course Outcomes

A student will be able to: know the concept of stochastic process, its specifications, and analyze the classification of states; construct Markov Chain for real world situations

Unit:1

Stochastic processes: Definition and classification – Markov chain– Examples (Random Walk, Gambler's ruin problem)- Transition Probability Matrices - Higher Transition Probabilities -Bernoulli Trails - classification of states and chains - theorems and problems; Basic limit theorem of renewal theory

Unit:2

Poisson Process: Overview- postulates- probability mass function -Properties - inter related probability distributions- Generalization- Arrival process, Departure Process, Pure Birth(Yule-Furry) process, Birth and Death Processes, Birth-Death and Migrations processes- Chapman Kolmogorov Equations- Compound Poisson Process - Transition density matrix and Poisson Process.

Unit:3

Weiner Process: Brownian Motion, Joint probabilities, Wiener process, Differential equations, Kolmogorov equations, First passage time distribution; Branching Process: properties of generating functions of branching processes, Probability of Ultimate extinction, Distribution of Total number of Progeny, Age dependent Branching process.

Unit:4

Renewal processes: Definition, examples and relationships between terms – renewal interval, delayed recurrent event, Renewal Processes in continuous time, Renewal Function and renewal density, renewal equation, renewal theorems – Study of residual life time process

Unit:5

Stationary processes and Time Series: Stationary Processes, second order, stationarity, Gaussian Processes, weakly and strongly stationary process; Time Series- White Noise process, first order Markov process, MA and AR processes, Autoregressive process of order two, ARMA process verification of stationarity.

Total Lecture Hours	**60 Hours**

Books for Study

1	Karlin, S and Taylor, H.M(1975): A First Course in Stochastic Processes, Academic Press, New York.
2	Medhi,J (2009): Stochastic Processes, 3/e, New age International.
3	Bhat B.R.(2004): Stochastic Models: Analysis and Applications, New Age Publications

Reference Books

1	Bhattacharya and Waymire, E.C. (1992): Stochastic Process with Applications John Wiley and sons.
2	Jones,P.W and Smith,P(2001): Stochastic Processes: An Introduction, Arnold Press.
3	Cinlar, E(1975): Introduction to Stochastic Processes, Prentice-Hall Inc., New Jersey.
4	Cox, D.R and Miller, H.D(1983) : Theory of Stochastic Processes – Chapman and Hall, London,Third Edition

Course Code	MJD - 13	OPERATIONS RESEARCH	L	T	P	Credits
Core	**MAJOR**	**Semester VI**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Mathematics (higher secondary level)				

Course Objectives	
To learn about decision theory and optimization techniques. To learn about game theory and network analysis	
Expected Course Outcomes	
A student will be able to: Gain knowledge to allocate resources in an optimal manner and also plan the time-line of projects.	
Unit:1	
Introduction to Operations Research – Principal Components of Decision problem – Phases of Operations Research – Various models in Operations Research. Linear Programming problem (LPP) – Formulation. Graphical Solution – Simplex method - Big M-Method and two-Phase methods – Principle of Duality – Conversion of primal to dual problems	
Unit:2	
Post Optimality and Sensitivity Analysis–Variation in cost vector and requirement vector–Addition and deletion of single variable and single constraint - Integer Programming Problem (IPP) - Gomory's cutting plane algorithm– Mixed IPP – Branch and Bound technique	
Unit:3	
Transportation Problem: Initial Basic Solution by North West Corner Rule, Least Cost and Vogel's Approximation Methods – Optimal solution by Modified Distribution Method (MODI) – Assignment problem – Simple problems	
Unit:4	
Sequencing problem: 'n' jobs and 2 machine problem – 'n' jobs and 'm' machine problems – 2 jobs and 'm' machine problem – Game Theory – pure and mixed strategies – saddle point - Optimal solution of two person zero sum game : Dominance property - Graphical Solution of (2 x n and m x 2) games	
Unit:5	
Network analysis: PERT and CPM - Basic Concepts - Steps in PERT/CPM techniques; Time estimates and Critical Path in Network Analysis; Optimum and minimum duration cost, PERT, Resource Allocations.	
Total Lecture Hours	**60 Hours**

Books for Study	
1	Hamdy.A.Taha(1999): Operations Research, 6^{th} Edition, Macmillan Publishing Co. Inc.
2	KantiSwarup et al.: Operations Research, Sultan Chand and Sons, New Delhi.
3	Goel and Mittal (1982): Operations Research, Pragati Prakashan, Meerut
Reference Books	
1	Hiller F.S. and Libermann G.J(2011): Introduction to Operations Research, McGraw Hill.
2	Sharma J.K.(2001): Operations Research: Theory and Applications, Macmillan India Ltd.
3	Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House.

Course Code	MJD - 14	STATISTICAL QUALITY CONTROL	L	T	P	Credits
Core	MAJOR	Semester VI	4	1	-	4
Pre-requisite						

Course Objectives

To give exposure on the practical implementation of the quality control techniques and acceptance sampling schemes.

Expected Course Outcomes

Students will be able to cater the needs of the industry to resolve the quality issues.

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. Product control – fundamental concepts of acceptance sampling by attributes – producer's and consumer's risk – concepts of AQL, LTPD, AQL and AOQL.

Unit:4

Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves –MILSTD-105E Tables.

Unit:5

Acceptance sampling variables for process parameter – Sequential plans for process parameter (σ known and unknown) – Sampling variables for proportion non-conforming - $\bar{X}$ method, K method – Double specification limits – M-method, Double sampling by variables - MILSTD -414 Tables – Continuous Sampling plan – CSP-1, CSP-2, CSP-3, Wald and Wolfowitz SP-A and SP- B.

Total Lecture Hours	**60 Hours**

Books for Study

1	Montgomery.D.C. (2010), Introduction to Statistical Quality Control: A Modern Introduction, 6th Edition, John Wiley and Sons.
2	S.C.Gupta and V.K.Kapoor(1999), Fundamentals of Applied Statistics, Sultan Chand and Sons
3	Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis

Reference Books

1	Mittage, H.J and Rinne, H(1993): Statistical Methods of Quality Assurance, Chapman Hall, London, UK.
2	Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.
3	Juran J.M and Frank M.Gryna Jr .(1982): "Quality Planning and Analysis", TMH, India.

Course Code	MJD - 15	STATISTICS PRACTICAL – II*	L	T	P	Credits
Core	**MAJOR**	**Semester VI**	**-**	**-**	**8**	**4**
Pre-requisite		Distribution Theory, Statistical Inference				

Course Objectives

This course is intended to train students to get knowledge in practical applications of Testing of Hypotheses, Design of Experiments, Regression Analysis and Statistical Quality Control.

Expected Course Outcomes

Students will be able to perform analysis of data sets using Calculator. Ability to solving statistical problems.

TESTING OF HYPOTHESES

1. Large Sample Tests: Means, Variances and Proportions
2. Test based on Chi-square distribution: Population variance, testing the goodness of fit, independence of attributed
3. Test based on t distribution: Single mean, Difference of means, Paired t test, Correlation coefficient
4. Test based on F distribution: Equality of two population variance
5. Non-parametric tests – Sign test, Wilcoxon test, Mann-Whitney U test, Median test, Run test, Kolmogorov – Smirnov one sample test

DESIGN OF EXPERIMENTS

1. ANOVA One-way and Two-way classification Model
2. Completely Randomised Design and Multiple Comparison Methods (LSD)
3. Randomised Block Design and R.B.D. with one or two missing values
4. Latin Square Design and L.S.D. with one or two missing values
5. 2^2 Factorial Design, 2^3 Factorial Design

REGRESSION ANALYSIS

1. Simple Linear Regression
2. Multiple Linear Regression model

STATISTICAL QUALITY CONTROL

1. $\bar{X}$, R and S charts
2. p chart and np chart
3. c chart and u chart
4. Single Sampling Plan and Double Sampling Plan
5. Sequential Sampling Plan

Evaluation Methodology: Break up Marks (Internal:**50**; End-Semester:**50**)

Course Code	MID - 6	STATISTICAL ANALYSIS USING R (Practical)*	L	T	P	Credits
Core	MINOR	Semester VI	-	-	8	4
Pre-requisite		Knowledge on algorithm and programming Knowledge on Statistical tests				

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
3. To impart skills in analyzing univariate and bivariate data.

Expected Course Outcomes

A student will be able to:
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

Introduction to R: R as a calculator, statistical software and a programming language,R preliminaries, getting help, data inputting methods (direct and importing from other spread Sheet applications like Excel), data accessing, and indexing, Graphics in R, built in functions, saving, storing and retrieving work

Unit:2

Descriptive statistics: diagrammatic representation of univariate and bivariate data, measures of central tendency, partition values, measures of dispersion, summaries of a numerical data, skewness and kurtosis, random sampling with and without replacement

Unit:3

Probability Distributions: R as a set of statistical tables- cumulative distribution, probability density function, quantile function, and simulate from the distribution, plotting probability curves for standard distributions

Unit:4

Statistical Inference: One- and two-sample tests, z-test, t-test, F-test, chi-square test of independence and goodness of fit, interval estimation for mean, difference of mean and variance, tests for normality

Unit:5

Correlation – Simple and Multiple regressions, Residual Analysis for model adequacy, detection of outliers and influential observations, Variable Selection Procedures, Collinearity Diagnostics – Analysis of Variance: CRD, RBD, LSD

Total Lecture Hours	**60 Hours**

Books for Study

1	Dr.Mark Gardener(2012), Beginning R The statistical Programming Languages, John Wiley & Sons
2	Sudha G. Purohit, SharadD.Gore, and ShailajaR.Deshmukh (2008), Statistics Using R, Narosa Publishing House, India

Reference Books

1	Michale J. Crawley (2009), THE R BOOK, John Wiley & Sons

Practical Exercises:

The Instructor or faculty incharge of the course will select and assign the practical exercise based on the syllabus

Evaluation methodology: (Practical)

Internal Assessment (Mid-Semester Exam) – 50 Marks End-Semester University Exam – 50 Marks

Course Code	MJD -16	PROBABILITY THEORY -II	L	T	P	Credits
Core	**MAJOR**	**Semester VII**	**4**	**1**	**-**	**4**
Pre-requisite		Basic Probability Theory				

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.

Unit:4

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:5

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 (statement only), Liapounov theorem – 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

Reference Books

1	Athreya K B and Lahiri S N (2005): Measure Theory, Hindustan Book Agency.
2	Tucker, H.G. (1967): A Graduate course in Probability, Academic Press.
3	Burill, C.W. (1972): Measure, Integration and Probability, McGraw Hill.
4	Loeve, M. (1985). Probability Theory, 3rd edition, Springer.
5	Resnick S.I. (2001): A Probability Path, Birkauser.
6	Basu A K. and A Bandopadhyay (2012): Measure Theory and Probability, PHI Learning Pvt. Ltd.

Course Code	MJD - 17	DISTRIBUTION THEORY - II	L	T	P	Credits
Core	**MAJOR**	**Semester VII**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge in Probability Theory				

Course Objectives

This course is intended to train students in mathematical techniques of constructing various univariate, bivariate and multivariate distributions

Expected Course Outcomes

Students will learn about the characterizations of univariate, bivariate and multivariate distributions, its applications and theory of order statistics.

Unit:1

Brief review of distribution theory, distribution of functions of random variables - Laplace, 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 and mixture of distributions, Concept of convolution

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 - Extreme values and their asymptotic distributions (concepts only)

Unit:5

Empirical distribution function and its properties - Kolmogorov-Smirnov distributions -Life time distributions - Exponential and Weibull distributions - Mills ratio -Distributions classified by hazard rate.

Total Lecture Hours	**60 Hours**

Books for Study

1	Mood M., Graybill F.A. and Boes D.C.(2001) : Introduction to the Theory of Statistics, Tata McGraw-Hill, New Delhi.
2	Johnson, N.L,Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, Vol.1 &2, Wiley Series in Probabilty and Statistics.
3	Johnson, N.L , Kemp A.W. & Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probabilty and Statistics
4	David H. A. and Nagaraja H.N.(2003): Order Statistics, 3/e, John Wiley & Sons

Reference Books

1	Rao C. R.,(1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd, New Delhi.
2	Dudewicz, E.J and Mishra, S.N(1980): Mathematical Statistics, John Wiley, NY.
3	Kocherlakota S and Kocherlakota K(1992): Bivariate Discrete distributions, M. Dekker.
4	Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.
5	Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
6	Parimal Mukhopadhyay (2006): Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata

Course Code	MJD - 18	STATISTICAL INFERENCE - I	L	T	P	Credits
Core	MAJOR	Semester VII	4	1	-	4

Pre-requisite	Estimation theory

Course Objectives

The objective of the course is to learn the basic concepts in estimation theory like consistency, sufficiency, UMVUE and their applications. To study different methods of estimation and their properties.

Expected Course Outcomes

Students will gain knowledge about various statistical estimation methods and their applications.

Unit:1

Parametric point estimation – properties of estimators – Consistency and its different forms Sufficient condition for consistency- Unbiasedness – sufficient statistics – Factorization theorem – Distributions admitting sufficient statistic – Exponential and Pitman families procedure for finding minimal sufficient statistic.

Unit:2

The information measure – Cramer – Rao (CR) inequality – Chapman – Robbins (KCR) inequality (single parameter case only) – Bhattacharya inequality (single parameter case only) – minimum variance bound estimator- Invariant (equivariant) estimators (concepts only)

Unit:3

Uniformly minimum variance unbiased estimators (UMVUE)- condition for the existence of UMVUE- Completeness and Bounded completeness- Relation between complete statistic and minimal sufficient statistic- Rao – Blackwell Theorem- Lehmann – Scheffe's theorem.

Unit:4

Methods of estimation – method of moments and its properties – method of maximum likelihood and its properties- Large sample properties of MLE - Method of minimum chi- square and its properties – Methods of least squares

Unit:5

Interval estimation – Pivotal method of construction – shortest confidence intervals and their construction (minimum average width) – Construction of shortest confidence intervals in large samples. Decision Theory: Simple problems involving quadratic error loss function – Elementary notions of minimax estimation – Simple illustrations

Total Lecture Hours	**60 Hours**

Books for Study

1	Casella, G. and Berger, R.L. (2002): Statistical Inference, Duxubury Process, Belmont, USA.
2	Rohatgi, V.K. (2003): Statistical Inference, Dover Publications, New York.

Reference Books

1	Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi
2	Lehmann, E.L and Casella G(1998) :Theory of Point Estimation, 2/e, Wiley Eastern Ltd.
3	B.K.Kale and K.Muralidharan (2015), Parametric Inference – An Introduction, Narosa Publishing House
4	Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House.
5	Zacks,S. (1981): Parametric Statistical Inference, John Wiley, NY.
6	Srivastava, Khan and Srivastava (2014), Statistical Inference: Theory of Estimation, PHI, India

Course Code	MID - 7	SAMPLING THEORY - II	L	T	P	Credits
Core	**MINOR**	**Semester VII**	**4**	**1**	**-**	**4**
Pre-requisite		Knowledge of Introduction to sampling theory				

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 create the knowledge understanding census and sample survey sampling methods and applying them in practice.

Expected Course Outcomes

Recognize the role of sampling theory in the sciences, it helps in learning various probability and non-probability sampling techniques and which experience how to draw a random sample and what amount of sample with respect to population to be drawn. which will be useful to the students and confidence building in taking decision of any object of the real life problems.

Unit:1

Preliminaries – Sampling Designs – Simple random sampling– Stratified Random Sampling – Allocation problems – Systematic Sampling Schemes – Linear, Circular, Balanced and Modified systematic sampling methods

Unit:2

Probability Proportional to size sampling- Inclusion Probabilities – Horvitz-Thompson estimator – Yates –Grundy Form –Midzuno Sampling design – PPSWOR- Des-Raj's Ordered estimator – Murty'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

Cluster Sampling: Equal cluster sampling – Estimators of mean and variance, optimum cluster size, Unequal cluster sampling – Estimators of mean and variance – Two stage sampling – variance of the estimated mean – Double Sampling for stratification and Ratio estimation

Unit:5

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

Total Lecture Hours: 60 Hours

Books for Study

1	Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley Eastern Ltd,.
2	Gupta, A. K. and Kabe D.G, (2011): Theory of Sample Surveys, World Scientific Publishing Co. Pte. Ltd., Singapore
3	Singh, D. and Choudhary, F.S (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd,.
4	Sukhatme PV. Etal. (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	Kish, L(1995) : Survey Sampling, John Wiley and Sons.
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	MID - 8	STATISTICAL ANALYSIS USING PYTHON (Practical)*	L	T	P	Credits
Core	MINOR	Semester VI	-	-	8	4
Pre-requisite						

Course Objectives

The main objectives of this course are to:
To learn about basics of python. To learn visualizing the data, data handling and performing inferential tests

Expected Course Outcomes

A student will be able to:
Understand how to install, perform basic operations. To visualize data using various codes and filters
Inferential aspects of testing means and variances. Model fit and residual analysis
Carry out analyses of multivariate techniques using various datasets

Unit:1

Introduction to Python – Origin of Python, why use of Python, Benefits of Python. Creating Python Platform. Interactive Development Environment – Setting working directory, packages, Import and Export of Excel, CSV files.

Unit:2

Python fundamentals – Statements, comments, indentation, Assigning variables, data types, input and output statements. Mathematical and statistical operators, conditional statements, loop statements, methods and arguments.

Unit:3

Diagrammatic representation – simple bar diagram, Multiple bar diagram, subdivided bar diagram, Pie diagram, Scatter plot, Histogram, Box plot. Measures of central tendency, Measure of dispersion.

Unit:4

Simple Correlation - Linear Regression – Multiple Linear Regression-Logistic Regression- Dealing with Multicollinearity

Unit:5

Parametric testing of Statistical Hypothesis – One Sample t test – independent sample t test – paired t test – one way ANOVA- two way ANOVA. Non- Parametric testing of Statistical Hypothesis – Sign Test – Wilcoxon – MannWitney – Kruskal Wallis

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	Rance D. Necaise (2018), Data Structures and Algorithms using Python, Wiley Student Edition
2	Donaldson, T (2014) Visual Quick start Guide Python, Pearson, 3rd Edition
3	William McKinney (2017), Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, O'Rilley

Practical Exercises:

The Instructor or faculty incharge of the course will select and assign the practical exercise based on the syllabus

Evaluation methodology: (Practical)

Internal Assessment (Mid-Semester Exam) – 50 Marks
End-Semester University Exam – 50 Marks

Course Code	MJD - 19	MULTIVARIATE ANALYSIS	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite		Distribution Theory and Matrices Concepts				

Course Objectives

The main objectives of this course are to:

To learn about multivariate normal distribution and its characterizations.

To study the multivariate tests for mean vectors and covariance matrices.

To know the concepts and applications of multivariate statistical methods like Discriminant Analysis, Principal Component Analysis, Canonical Correlation Analysis & Factor Analysis

Expected Course Outcomes

A student will be able to:

1. Understand the concepts and applications and multivariate normal distribution
2. Inferential aspects of testing mean vectors and covariance matrices, perform modeling to classify the data into k populations and dimensionality reduction of data into meaningful components.

Unit:1

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

Unit:2

Total, Partial, Multiple correlation in the Multivariate setup – MLEs of Total, Partial and Multiple correlation coefficients. Sampling distributions of Total and Multiple Correlation in the null case. Hotelling T^2 statistic, derivation and its distribution –Uses of T^2 statistic - relation between T^2 and D^2– Mahalanobis D^2 statistic and its distribution

Unit:3

Generalized variance – Wishart distribution (statement only) – Properties of Wishart distribution – Test for covariance matrix – Test for equality of covariance matrices

Unit:4

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

Unit:5

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. (2003) : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
2	Johnson, R. A and. Wichern D.W (2007): Applied Multivariate Statistical Analysis, 6 /e, Prentice-Hall of India Private
3	Giri, N.C(2003): Multivariate Statistical Inference, Academic Press, NY

Reference Books

1	Morrison, F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
2	Rao, C.R(1998): Linear Statistical Inference and its Applications, Wiley Eastern Ltd,.
3	Alvin C. Rencher(2002): Methods of Multivariate Analysis, 2/e, Wiley Interscience
4	Srivastava M.S. and Khatri C.G.(1979):Introduction to Multivariate Analysis, Elsevier

Course Code	MJD - 20	STATISTICAL INFERENCE - II	L	T	P	Credits
Core	**MAJOR**	**Semester VIII**	**4**	**1**	**-**	**4**
Pre-requisite		Statistical tests				

Course Objectives

The main objectives of this course are:
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 impart knowledge on invariant, Likelihood ratio test methods and non-parametric test procedures

Expected Course Outcomes

A student will be able to perform analysis of data to solve statistical problems.

Unit:1

Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, Most powerful tests, Uniformly most powerful test, Uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma and its applications

Unit:2

Unbiasedness for hypothesis testing, Uniformly most powerful unbiased tests, Unbiased tests for one parameter exponential family, Similar test and complete sufficient statistics, Similar tests with Neyman structure, Locally most powerful tests.

Unit:3

Invariant tests, maximal invariants, Uniformly most powerful invariant tests, Consistent tests, Likelihood ratio test, its properties and its asymptotic distribution, Applications of the LR method.

Unit:4

Non-parametric tests: Goodness of fit test : Chi-square and Kolmogorov Smirnov test - Test for randomness, Wilcoxon Signed rank test – Two sample problem: Kolmogrov-Smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test, Kruskal Wallis test and Friedman's test

Unit:5

Sequential tests: Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications – Determination of the boundary constants – Operating Characteristic and expected sample size of SPRT – Optimum properties of SPRT.

Total Lecture Hours	**60 Hours**

Books for Study

1	Lehmann, E.L and Joseph P. Romano (2005): Testing Statistical Hypotheses, 3/e, Springer
2	Rohatgi, V.K.(2003): Statistical Inference, Dover Publications,.
3	Gibbons, J.D. (1985) : Non Parametric Statistical Inference , 2/e , Marckel Decker

Reference Books

1	Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi
2	Casella, G & Berger, R.L (1990):Statistical Inference , Duxubury Press, Belmont. USA
3	Ghosh,B.K(1970): Sequential Tests of Statistical Hypotheses, Addison Wesley.
4	Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
5	Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India.

Course Code	MJD - 21	DESIGN OF EXPERIMENTS - II	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite		Design of experiments				

Course Objectives

The main objectives of this course are:

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

A 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

Unit:1

Full rank linear model – least square estimators of the parameters and their properties – Gauss-Markov theorem – Model in centered form – Estimators under normality assumption and their properties – Coefficient of determination – Generalized least squares – misspecification of the error structure and the model.

Unit:2

Notion of design matrix- general analysis of design models (Inter and Intra Block analysis) – C Matrix and its properties – Expected Mean Squares (EMS) and its uses- Algorithm for calculating EMS – Two-way elimination of heterogeneity – Orthogonality – Connectedness and resolvability.

Unit:3

Analysis of Covariance (ANCOVA) – CRD One Concomitant Variable and RBD One Concomitant Variable

Unit:4

Factorial experiments: 2^4 and 3^2, 3^3 experiments and their analysis – Complete and Partial Confounding - Fractional Replication in Factorial Experiments

Unit:5

Balanced Incomplete Block Design (BIBD)– Types of BIBD – Simple construction methods – Concept of connectedness and balancing – Intra Block analysis of BIBD – Recovery of Inter Block information – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only - Split plot and strip plot design and their analysis.

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	Searle, S.R (1987) : Linear Models, John Wiley and Sons.

Reference Books

1	Cochran .W.G. and Cox .G.M. (1995): Experimental designs, 4/e, Wiley.
2	Kabe D. G. and Gupta A. K. (2007): Experimental Designs: Exercises and Solutions, Springer-Verlag, New York
3	Klaus Hinkelmann and Kempthorne, O. (1994): Design and Analysis of Experiments, John Wiley and Sons.
4	Parimal Mukhopadhyay(2005): Applied Statistics, 2/e, Books and Allied (P) Ltd, Kolkata.

Course Code	MJD -22	STATISTICS PRACTICAL – III * (based on Calculator/ Excel / R /Python as per suitability)	L	T	P	Credits
Core	MAJOR	Semester VIII	-	-	8	4

Pre-requisite

Course Objectives

This course is intended to train students to get knowledge in practical applications of Hypothesis testing, Multivariate analysis and Design of experiments.

Expected Course Outcomes

Students will be able to perform analysis of data sets using calculator/excel/ R programming/ python

STATISTICAL INFERENCES

1. Construction of randomized and nonrandomized MP, UMP and UMPU tests of hypotheses and drawing the power curves.
2. Construction of SPRT and its OC and ASN curves.

MULTIVARIATE ANALYSIS

1. Test for equality of mean vectors when covariance matrix is unknown (Hotelling's T^2 test)
2. Test for Two Covariance matrices
3. Discriminant Analysis
4. Canonical correlation and canonical variables
5. One Way MANOVA with Post hoc tests (DMRT and Tukey's).
6. Principal Component Analysis
7. Factor Analysis

DESIGN OF EXPERIMENTS

1. 2^4 , 3^2 factorial experiments
2. Fractional factorial experiments
3. Complete confounding in 2^4, 3^2 factorial experiments
4. Partial confounding in 2^4, 3^2 factorial experiments
5. Split plot design
6. BIBD
7. Analysis of Covariance – CRD One Concomitant Variable and RBD One Concomitant Variable

Evaluation Methodology: Break up Marks (Internal:**50**; End-Semester:**50**)

Course Code	MJD- 23	INDIAN OFFICIAL STATISTICAL SYSTEMS	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite						

Course Objectives

To learn about the Indian Official Statistical Systems

Expected Course Outcomes

Students will get an awareness about the Indian Official Statistical Systems, Its role and functions. Students will understand the importance of official Statistics and its collections methods. Awareness about capacity building and career opportunities.

Unit:1

Indian Official Statistical Systems: History of Indian Official Statistical Systems, Present Indian Official Statistical Systems. Flow chart of Indian Official Statistical Systems. Ministry of Statistics and Programme Implementation (MOSPI) and it wings - Vision and Mission, Divisions and important activities

Unit:2

National Statistical Commission (NSC) – Need, Composition, Functions of the NSC, Legal Acts/Provisions/Support for Official Statistics like Collection of Statistics Act, 2008. Important/Uses of Official Statistics.

Unit:3

The States Official Statistical Systems: Directorate of Economics and Statistics (DES): Role of DES – Common Statistical Cadre – Statistical Divisions in Departments – Block Statistical Organization.
Administrative Statistical System: Centralised and Decentralised Systems of Collection of Official Statistics. Improving the Administrative Statistical System (AdSS) – Statistics for Decision Making – Operational Aspects – Computerization of Administrative Statistics

Unit:4

Select Sector-wise Statistics and Human Resource Development: Agriculture, Health, Education and Employment. Staffing Pattern at the Centre, Indian Statistical Service and Subordinate Statistical Service.

Unit:5

National Statistical Systems Training Academy (NSSTA), MOSPI and its Capacity Building Activities.

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	https://www.mospi.gov.in/
3	https://nssta.gov.in/
4	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	MJD- 23	BIOSTATISTICS	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite		Statistics				

Course Objectives

Enable the students to understand the basic preliminaries and advanced modeling techniques applied in biological and medical sciences.

Expected Course Outcomes

This course will enhance the capability in handling practical situations that arise in pharmaceutical and health care industries.

Unit:1

Statistical Methods in Clinical Trials: Introduction to clinical trial and it's phases I, II, III and IV, statistical designs-fixed sample trials: simple randomized design, stratified randomized crossover design; Sequential design - open and close sequential design. Randomization-Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple.

Unit:2

Biological Assays: Introduction, parallel-line assay, slope- ratio assays and quantile- response assay, Feller's theorem. Dose-response relationships-qualitative and quantitative response, dose response relation- estimation of median effective dose – PK-PD Analysis.

Unit:3

Categorical Data Analysis: Categorical response data, logistic regression-odds ratio, Wald's statistic, logistic regression and its diagnostics, - Poison regression – Estimation of relative risk and its applications

Unit:4

ROC Curve analysis - Estimation of Binomial Model and the Area under the Curve, its applications – Properties of ROC curve - Kullback –Leibler Divergence (KLD)– definition – functional relationship between Kullback –Leibler Divergence and the slope of the ROC curve – derivations of KLD expressions for Bi-normal ROC model

Unit:5

Repeated Measures ANOVA – One Way and Two Classified Data –Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias – information bias and selection bias

Total Lecture Hours	**60 Hours**

Books for Study

1	Elisa T.Lee & John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley
2	Jerrold H. Zar (1999): Biostatistical Analysis, 4th edition, Pearson
3	Armitage, P, Berry G and Mathews J.N.S (2002): Statistical Methods in Medical Research, 4/e, Blackwell Scientific Publications
4	Krzanowski, W and Hand, D.J.(2009): ROC Curves for Continuous Data, Chapman and Hall

Reference Books

1	Hosmer and Lemeshow (2000): "Applied Logistic Regression", 2/e, Wiley Series
2	Alan Agresti (2002): Categorical Data analysis, 2/e, John Wiley
3	Sylvia Wasserthial and Smoller, (2004): Biostatistics and Epidemiology – A Primer for Health and Biomedical professionals, 3rd Edition, Springer
4	Rastogi, V.B. (2006): Fundamentals of Biostatistics, ANE Books, India

Course Code	MJD - 23	RELIABILITY THEORY	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite		Knowledge in Probability Distributions				

Course Objectives

To aware about the dealing of life time data in engineering and medical sciences, to learn several methods in reliability theory as well as survival analysis, apply these techniques to prevent or to reduce the likelihood or frequency of failures

Expected Course Outcomes

To predict the life time of subject and to know the pattern of rate of failure and compare the treatments in medical sciences

Unit:1

Introduction to Reliability and its needs; 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

Life Distributions: Concept of distribution function, hazard function, Reliability function, MTTF, Bathtub failure rate; loss of memory property of Exponential distribution - parametric families of some common life distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation of parameters in these models.

Unit:3

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.

Unit:4

Univariate stock models and life distributions arising out of them: cumulative damage model, shock models leading to univariate IFR, Successive shock model; bivariate shock models; common bivariate exponential distributions due to shock and their properties.

Maintenance and replacement policies; availability of reparable systems; modeling of a repairable system by a non-homogeneous Poisson process.

Unit:5

Stress-Strength reliability - Concepts and its estimation for exponential, Weibull and gamma distributions; Reliability growth models; probability plotting techniques; Hollander –Proschan and Despande tests for exponentiality – Basic ideas 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.

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

Course Code	MJD - 23	QUEUEING AND INVENTORY THEORY	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite		Basics in Stochastic processes				

Course Objectives

To Know about various descriptions, characteristics, related random processes and background themes of P*oisson Queuing Models with single server*, and *multiple server*. To study the assumptions and derivations of different mathematical relations like steady state equations, Queue characteristics of Non Poison (Erlangian) Queuing Models.
To Study the fundamental notions, applications and scope of Probabilistic and Deterministic Inventory Models.

Expected Course Outcomes

Derivation of and problem solving characteristics on queuing models, simple numerical problems. Derivations and problem solving of steady state equations for different processes such as birth, death, migrations and Poisson, different queuing models. Derivations and problem solving of EOQ, Optimal Total Cost, Optimal number of runs and optimal ordering times in deterministic inventory models with and without shortages.

Unit:1

Poisson Queuing Models with single server: Descriptions of queuing models, Generalized Birth and Death Processes, steady state Birth and death processes- Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/1): (□/FIFO) and (M/M/1): (N/FIFO) Models, simple problems

Unit:2

Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/C): (□/FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, simple numerical problems

Unit:3

Non-Poison Queuing Models (Erlangian): Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/Ek/1), (Ek/M/1), simple problems

Unit:4

Scope and notion of Inventory, Terminology, overview on probabilistic& Deterministic Models, optimality issues with Inventory; Deterministic Inventory models with shortages and without shortage. Finding EOQ and other characteristics, Simple Problem

Unit:5

Deterministic Inventory models with simultaneous replenishment and stock clearance, with shortages and without shortages, finding EOQ and other parameters, Simple Numerical Problems; Deterministic Inventory models with Single and multiple price Breaks and numerical examples.

	Total Lecture Hours	60 Hours

Books for Study

1	KantiSwarup et al.:Operations Research, Sultan Chand and Sons,New Delhi
2	S.D Sharma: Operations Research
3	Donald Gross & Carl M Harris (1998): Fundamentals of Queuing theory, John Wiley & Sons, Inc.
4	Hamdy A.Taha(2006): Operations Research – An Introduction, 8/e , Prentice Hall of India Private Ltd., New Delhi

Reference Books

1	Hiller F S and Libermann G J (1995):Introduction to operations Researsch, 6^{th} Edition, McGraw Hill
2	Prabhu N.U. (1965) Applied Stochastic Processes, Mc.Millan
3	J.Medhi (2009), Stochastic Processes, 3/e, New Age International
4	Bhat. B.R. (2002), Stochastic Processes, 2/e, New Age International

Course Code	MJD - 23	STATISTICAL DATA MINING METHODS	L	T	P	Credits
Core	MAJOR	Semester VIII	4	1	-	4
Pre-requisite						

Course Objectives

This course is intended to equip students to get knowledge in clustering and classification techniques.

Expected Course Outcomes

Students will gain knowledge on the working principle of algorithms related to clustering and classification techniques and its application to real life problems.

Unit:1

Introduction to data mining – data types – Measures of similarity and dissimilarity – Data mining tools – supervised and unsupervised learning – Introduction to Cluster Analysis – Types of clustering – Agglomerative Hierarchical clustering algorithm – Issues – strength and weaknesses.

Unit:2

Basic k-means algorithm – Issues – fuzzy clustering – fuzzy c means algorithm - cluster evaluation – unsupervised and supervised measures - Introduction to classification – Decision Trees – Building a decision tree – Tree induction algorithm – model over fitting – Evaluating the performance of a classifier

Unit:3

Nearest Neighbor classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression

Unit:4

Association rules mining – Basics – Apriori algorithm – Pruning and candidate generation – Rule mining.

Unit:5

Case studies based on k means clustering - fuzzy c means clustering - kNN classification - Binary logistic regression using R programming language

Total Lecture Hours	**60 Hours**

Books for Study

1	Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education. (relevant portions of Chapters 1, 2, 4, 5 and 8)
2	Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd. (relevant portions of Chapter 2)
3	Daniel T. Larose (2006): Data Mining: Methods and Models, John Wiley and sons. (relevant portions of Chapter 4)

Reference Books

1	Han, J. and Kamber, M. (2006): Data Mining: Concepts and Techniques, 2nd Edition, Morgan Kaufmann Publishers
2	Paolo Gludici (2003): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley and sons
3	Rajan Chattamvelli (2009): Data Mining Methods, Narosa Publishing House, New Delhi

Guidelines for Research Project / Dissertation (12 Credits)

Objective

To develop students' research aptitude by allowing them to independently explore a topic in **one major discipline of Statistics**, guided by a faculty supervisor**.**

The **Research Project / Dissertation** is a **12-credit course** structured as follows:

- 4 Credits **–** for the subject chosen as the research area and literature review.
- 4 Credits – for project work/dissertation report preparation and submission.
- 4 Credits – for the viva-voce examination.

This credit distribution ensures that students are assessed comprehensively on topic selection, research execution, documentation, and oral defense of their work.

General Instructions

- Students must choose one specialised area within the major discipline (Statistics) in consultation with the assigned supervisor**.** The topic must reflect the faculty member's area of expertise to ensure proper guidance.
- A faculty member will guide each student or group. Students must consult and get topic approval before proceeding. Regular reviews should be conducted. Research projects can be theoretical, simulation-based, or applied**.**
- Hard copy (soft-bound) and Soft copy (PDF) should be submitted on or before the notified deadline**.**

Structure of the Dissertation Report

The final report should follow this format:

1. **Cover Page** (with title, student name, roll number, supervisor name, institution, year)
2. **Certificate by Supervisor**
3. **Declaration by Student**
4. **Acknowledgment**
5. **Abstract**
6. **Table of Contents**
7. **Chapters**:
    - **Chapter 1: Introduction**
        - Background, objectives, scope, significance
    - **Chapter 2: Literature Review**
    - **Chapter 3: Methodology**
        - Data source, sampling, tools used, statistical software (if any)
    - **Chapter 4: Data Analysis and Interpretation**
    - **Chapter 5: Findings, Conclusion, and Recommendations**
8. **References/Bibliography**
9. **Appendices** (Questionnaire, Code, Tables, etc.)

Presentation during research work - 50 Marks

Atleast two presentations before a departmental committee about Objectives, Methodology, etc.

Final Presentation (Viva Voce) - 50 Marks

A presentation before a departmental committee. Must include: Objectives, Methodology, Key findings, Challenges faced and Scope for future research.