PERIYAR UNIVERSITY

Re-accredited with 'A' grade by the NAAC

PERIYAR PALKALAI NAGAR

SALEM – 11

M.Sc., Statistics

(SEMESTER PATTERN)

(Under Choice Based Credit System)

(For Periyar University Department)

REGULATIONS AND SYLLABUS

(Candidates admitted from 2018 - 2019 onwards)

1. PERIYAR UNIVERSITY VISION AND MISSION

Vision

- Periyar University aims towards excellence in education, research, promoting invention, innovation and preserving cultural identity for future generation.

Mission

- Provide a vibrant learning environment, fostering innovation and creativity inspired by cutting edge research
- Aspire to be a national leader in developing educated contributors, career ready learners and global citizens
- Provide well equipped facilities for teaching, research, administration and student life
- Have well defined autonomous governance structure
- To make a significant, consistent and sustainable contribution towards social, cultural and economic life in Tamil Nadu, India.

Values

- Motivation of students to be responsible citizens making them aware of their societal role
- Inculcate scientific temper, honesty, integrity, transparency, empathy and ethical values amidst students
- Impart a desire for lifelong learning to foster patriotic sensibility, accountability and holistic well being
- Provide conducive and cosmopolitan environment for innovation and free thinking.
- Imbibe value based education leading to inclusive growth.

Goals

- Become a global leader in teaching, research, invention and innovation
- Make significant contribution to advancement of knowledge through quality teaching and innovative research
- Produce graduates possessing creativity and reflective thoughts, strong analytical skills and a passion for learning
- Be a part in social and economic upliftment of society to infuse sense of social and national responsibility among students.

2. DEPARTMENT VISION AND MISSION

Vision

- To centre stage statistical knowledge in the curriculum in-still analytical and logical thinking among students and promote statistical thought as an important area of human thought.

Mission

- To encourage students to conduct student projects to develop their analytical and logical thinking.
- To establish industry links to develop statistical models and help the industry.
- To conduct outreach programmes for the socially marginalized students.
- The department creates an environment where the faculty and continue to grow as teachers and scholars, while providing public and professional service.

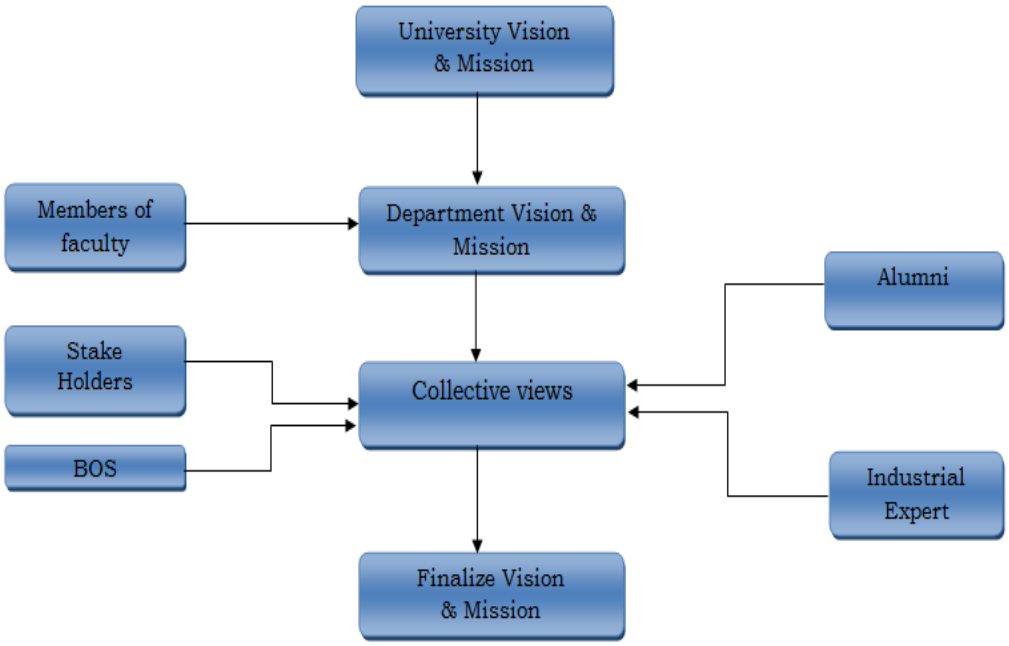
The Process for Defining Vision and Mission of the Department

The following steps are followed to establish Vision and Mission for the Department of Statistics;

- Step 1: The Vision and Mission of the Periyar University is taken as the basis.
- Step 2: The Department conducts brain-storming sessions with the faculty members on the skill-set required by the local and global employers, Industry Advances in Technology and R and D, and the draft copy of the Vision and Mission of the Department is drafted.
- Step 3: The views from Stake Holders, Industrial Experts and Board of Studies (BOS) on the draft are also collected and incorporated to revise the draft version based on their inputs.
- Step 4: The accepted views are analyzed and reviewed to check the consistency with the vision and mission of the institute.

The process for defining department vision and mission are illustrated in the flow chart Figure 2.1.

FIGURE 2. 1: DEPARTMENT VISION AND MISSION



3. PROGRAM EDUCATIONAL OBJECTIVES, PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

3.1 Program Educational Objectives (PEOs)

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.

3.2 Program Outcomes (POs)

Program outcomes describe what students are expected to know and would be able to do by the time of Post-Graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program.

3.3 Program Specific Outcomes (PSOs)

Program Specific Outcomes are statements that describe what the Post Graduates of a specific Science Programme should be able to do.

4. STATEMENTS OF PEOs, POs AND PSOs

4.1 PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1-Professional Development

To develop in the students the ability to acquire knowledge of Statistics, Mathematics & Software Computations and apply it professionally within realistic constraints such as economic, environmental, social, political, ethical, health and safety and sustainability with due ethical responsibility.

PEO2-Core Proficiency

To provide ability to identify, formulate, comprehend, analyze, design and data analytics with hands on experience in various technologies using modern tools necessary for theoretical research and data processing practice to satisfy the needs of society and the industry.

PEO3- Technical Accomplishments

To equip the students with the ability to design, simulate statistical experiments, analyze, optimize and interpret in their core applications through multi-disciplinary concepts and contemporary learning to build them into industry ready Post Graduates.

PEO4- Professionalism

To provide training, exposure and awareness on importance of soft skills for better career and holistic personality development as well as professional attitude towards ethical issues, team work, responsibility, accountability, multidisciplinary approach and capability to relate data analysis issues to broader social context.

PEO5- Learning Environment

To provide students with an academic environment and make them aware of excellence, develop the urge of discovery, creativity, inventiveness, leadership, written ethical codes and guidelines and the life-long learning to become a successful professional in Statistics.

4.2 THE PROCESS FOR ESTABLISHING THE PEO's

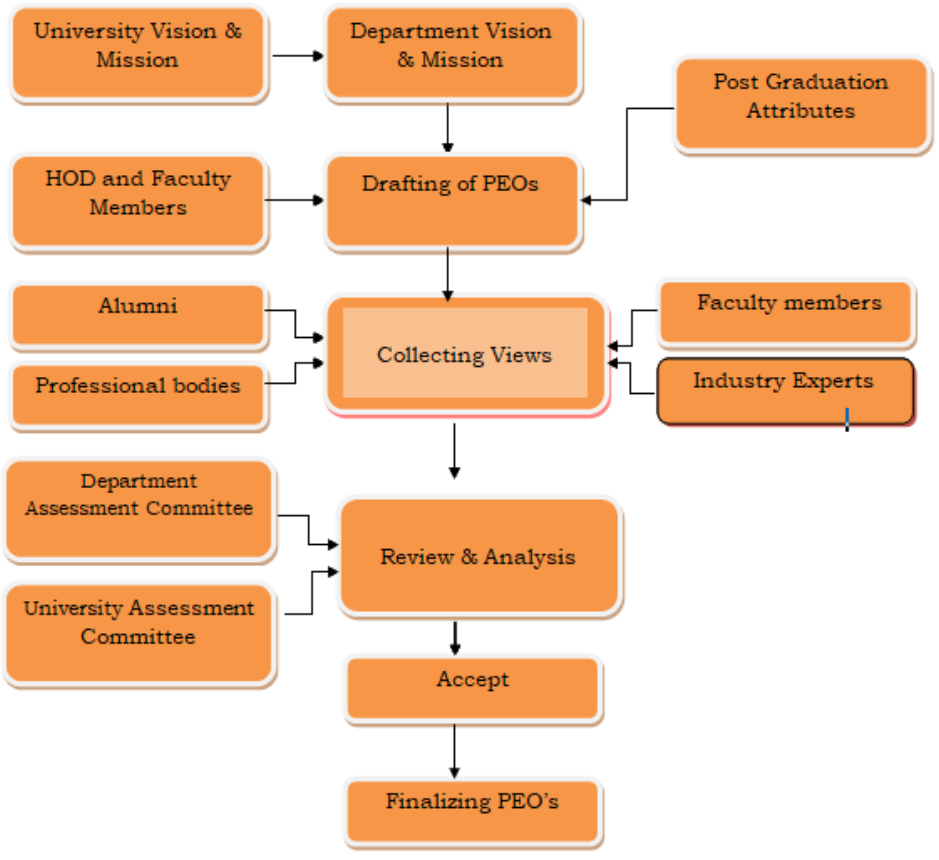
The PEOs are established through the following process steps:

- **Step 1:** Vision and Mission of the University and Department are taken into consideration to interact with various stake holders, and establish the PEO's.

- **Step 2:** The Head of the Department, Members of Faculty, Professionals from Industry and BOS members prepares the draft version of PEOs and POs.
- **Step 3:** The draft version is discussed with stakeholders and their views are collected by the Head of the Department.
- **Step 4:** The Department Assessment Committee reviews and analyzes the PEOs and POs and submits its Recommendations to the Departmental advisory Board.
- **Step 5:** The Departmental advisory Board deliberates on the recommendations and freezes the PEOs and POs and submits them to the University Committee for final approval.

The Programme curriculum is designed by incorporating inputs from members of Board of Studies and Academic council who are drawn from various academic institutions, R&D organizations and industry. Inputs are also obtained from alumni and other stake holders. Besides, a skill in demand analysis is carried out periodically to identify the core areas in the Statistics domain that are consistent with industry needs. Thus the PEOs are established, checked for consistency with the mission statement of the department.
The process steps followed for establishing the PEO's for M.Sc., Statistics Programme are illustrated in the flow chart Figure 4.1.

Fig. 4.1.: ESTABLISHING THE PROGRAMME EDUCATIONAL OBJECTIVES



4.3 PROGRAMME OUTCOMES (PO's):

The Post Graduates of the M.Sc. (Statistics) Programme will enable:

- Professionally inclined Statistics educators who have sound knowledge of subject matter and specialized in constructivist & alternate pedagogy
- Contribute as researchers in curriculum design and in evaluation reforms to raise the standard of Statistics education.
- Contribute as trained work force to provide teaching-learning support to schools as a part of extension activity using ICT in Statistics teaching in multiple ways
- Develop need based Statistics teaching-learning resources

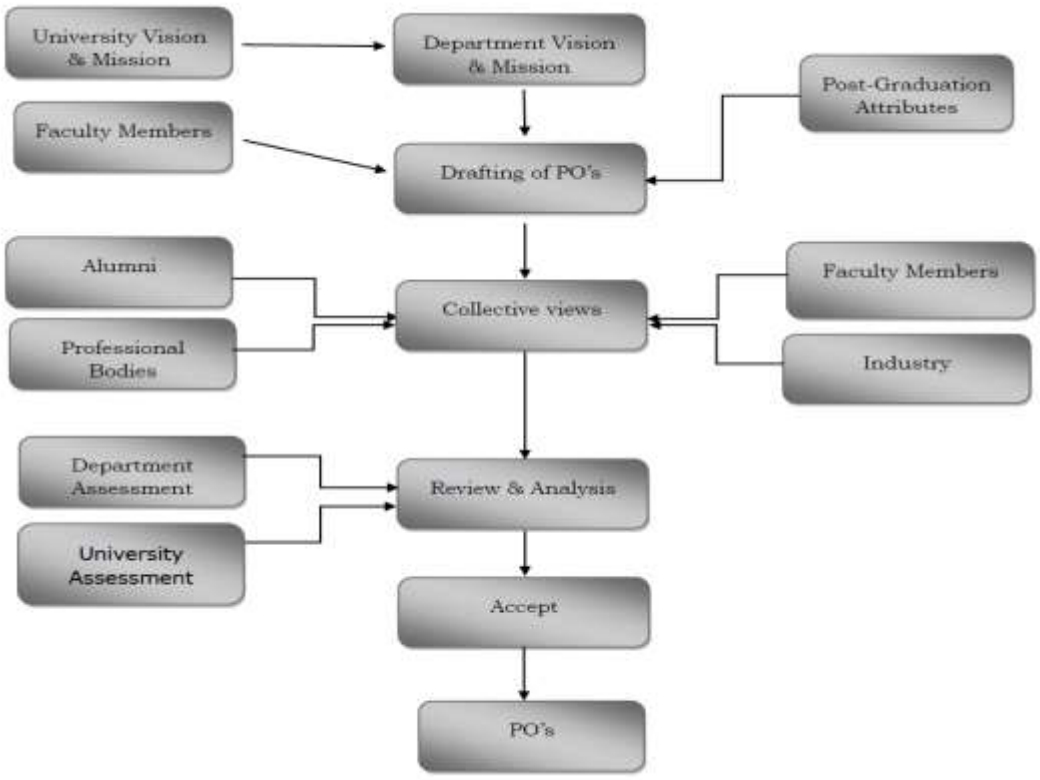
PROGRAMME OUTCOMES		
PO1	**Subject Knowledge**	An ability to apply knowledge of mathematical statistics including statistics, mathematics, computer programming and data analytics to solve Statistical/Analytical problems
PO2	**Problem Analysis and Developing Solutions**	An ability to design, simulate data, as well as to analyze and interpret data to meet desired specific solutions using appropriate data analysis/statistical tools
PO3	**Investigations Of Complex Problems and Modern Tool Usage**	An ability to identify, formulate, comprehend and analyze the synthesis of the information to solve using the techniques, skills and modern statistical packages which are necessary for real time data analysis and provide valid conclusions
PO4	**The Statistician and The Society, Environment And Sustainability**	The broad education should provide necessary understanding on professional, health, safety, legal and cultural with an impact of statistical solutions to benefit the Society, Economy, and Environment and demonstrate the knowledge on Sustainable development.
PO5	**Team Work, Ethics and Life-Long Learning**	Apply ethical principles to work as a member and leader in a multi-disciplinary team to resolve contemporary issues and acquire lifelong learning

4.4 The Process for Establishing the PO's

The POs are established through the following process steps:

The process steps followed for establishing the PO's for M.Sc., Statistics Programme are illustrated in the flow chart Figure 4.2.

FIG. 4.2.: ESTABLISHING THE PROGRAMME OUTCOMES



The Vision, Mission PEOs of the Department along with the five Post Graduate Attributes given by the NAAC is used in defining the POs;

- **Step 1:** The Head of the Department consults the key constituents, Faculty Members and collects their views and prepares the draft version of the PEOs and POs.
- **Step 2:** The HOD then gather views from the Alumni, Professional Body representatives, Industry representatives / Employer along with the faculty and revise the draft.
- **Step 3:** The Department Assessment Committee analyzes and expresses its opinion on the revised PEOs and POs and forwards the same for final approval to University Advisory Board.
- **Step 4:** University Advisory Board deliberate on the views expressed by the Programme Assessment Committee and formulate the accepted views based on which POs are to be established.

4.5 PROGRAM SPECIFIC OUTCOMES (PSO's):

The Post Graduates of the Statistics Department will Attain:

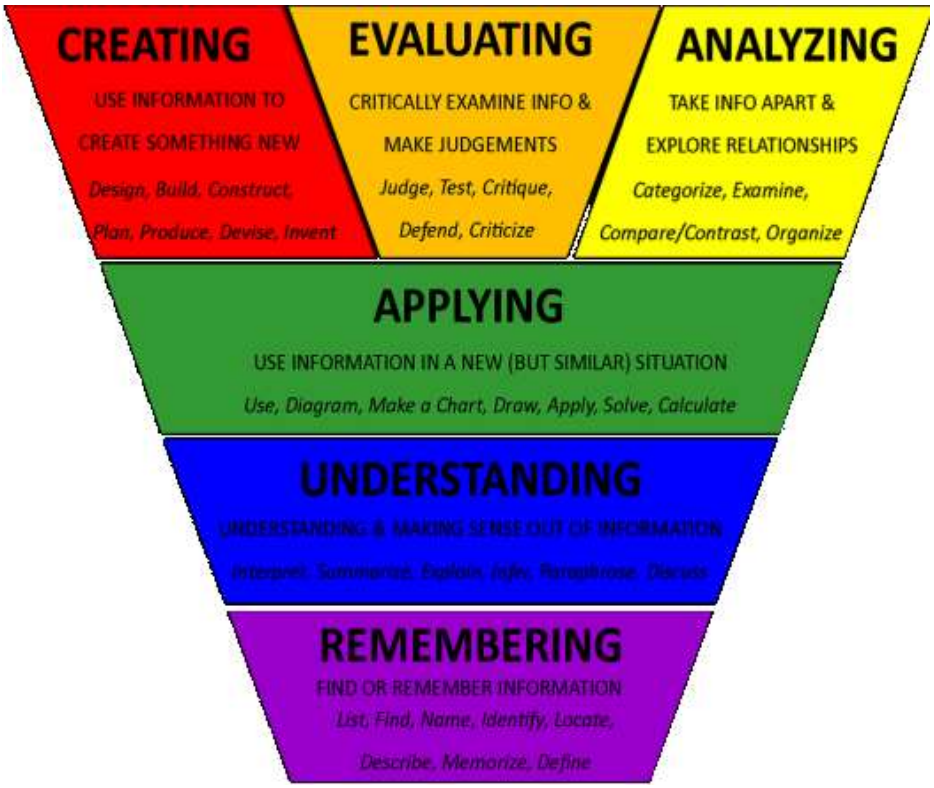
PSO1: The ability to analyze and implement application specific theory and analysis for complex statistical problems in Optimization, Queuing Theory, Quality Control, Design of Experiments, Bio Statistics and Data analytics by applying the knowledge of basic Mathematical Statistics fundamentals.

PSO2: The ability to adapt for rapid changes in tools and technology with an understanding of societal and real time industrial issues relevant to professional statistical practice through life-long learning.

PSO3: Excellent adaptability to function in multi-disciplinary work environment, good interpersonal skills as a leader in a team in appreciation of professional ethics and societal responsibilities.

5. BLOOM'S TAXONOMY

FIG. 5.1 PICTORIAL REPRESENTATION OF BLOOM'S TAXONOMY



Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr. Benjamin Bloom in order to promote higher forms of thinking in education, such as analyzing and evaluating concepts, processes, procedures, and principles, rather than just remembering facts. It is most often used when designing educational, training, and learning processes.

BLOOM'S TAXONOMY		
Domains	**Keywords**	**Example**
Remembering Recall or retrieve previous learned information.	Defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.	Recite a policy. Quote prices from memory to a customer. Recite the safety rules.
Understanding Comprehending the meaning, translation, interpolation, and interpretation of instructions and Problems. State a problem in one's own words.	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, Summarizes, translates.	Rewrite the principles of test writing. Explain in one's own words the steps for performing a complex task. Translate an equation into a computer spread sheet.
Applying Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place.	Applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses.	Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test.
Analyzing Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences.	Analyzes, breaks down, compares, contrasts, and diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.	Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training.
Evaluating Make judgments about the value of ideas or materials.	appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports	Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget.
Creating Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure.	categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes	Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises process to improve the outcome.

6. COURSE OUTCOMES

6.1 Course Outcome Statement

Statements indicating what a student can do after the successful completion of a course. Every Course leads to some Course Outcomes. The CO statements are defined by considering the course content covered in each module of a course. For every course there may be 4 or 5 COs. The keywords used to define COs are based on Bloom's Taxonomy.

Perspectives in Statistics Education upon Completion of this course the students will be able to:

- Understand Statistics education as an academic and research field.
- Discuss the nature of Statistics with reference to pure and applied Mathematical Statistics.
- Analyze nature of statistics from cognitive to social perspective.
- Define specific components of statistics (axioms, postulates, paradoxes, mathematical statements, theorem and proof).
- Develop an understanding of philosophical, cultural, social, historical and psychological facets of statistics education.
- Discuss and analyses the history of Mathematical Statistics with respect Demography, Statistical Quality Control, Design of Experiments, Hypothesis Testing, Estimation Theory, Multivariate Analysis, Distribution Theory, Sampling Theory, Time Series Analysis.
- Apply the history and development of field of Mathematical Statistics in the present statistics curriculum.
- Critically analyze the present statistics curriculum.

6.2 Learning ways of Statistical Writing

Upon Completion of this course the students will be able to:

- Describe features of Statistics as a language
- List out symbols and notations used in Statistical writing
- Identify errors in Statistical writing
- Writing Statistical content in Latex (or appropriate software)

6.3 Art of Teaching Statistics

Upon Completion of this course the students will be able to:

- Define constructivists paradigm of learning
- Apply constructivists theories of learning in classroom practices
- Prepare lesson plans to address the pedagogical concerns in Probability and Measure theory, Linear Algebra, Quality control, Statistical inference, sampling theory
- Develop interdisciplinary Statistical projects based on school curriculum
- Use project method based teaching to develop comprehensive assessment plan in Mathematical statistics classroom
- Develop and use concept and age appropriate Statistical models to be used as 'hands-on' approach for teaching Statistics

6.4 Digital Technologies in Statistics Education

Upon completion of this course the students will be able to:

- Apply basic ICT skills in planning and teaching Statistics at school level
- Create web-based learning environment using blogs, virtual classrooms and web based
  Educational applications
- Use Statistics specific software, such as R Programming, MATLAB, Minitab, Stata, E-views, SAS, Python, S-Plus
- Use design software such as Photoshop, documentation software such as LATEX and others to create need based e-learning resources for students
- Teach Statistics by organizing virtual classrooms

6.5 Research Methodology in Statistics Education

Upon completion of this course the students will be able to:

- Understand need and scope of research
- Outline the process of conducting research
- Identify potential research areas in the field of Statistics viz. Optimization, Queuing Theory, Quality Control, Design of Experiments, Bio Statistics and Data analytics
- Write null hypothesis/alternate hypothesis for any research problem
- Differentiate among various research designs, such as experimental research, descriptive research, quasi-experimental research and others
- Write synopsis for a chosen area of research
- Choose and apply appropriate statistical techniques for various kinds of data collected under study

6.6 Research Investigations in Statistics Education

Upon completion of this course the students will be able to:

- Develop critical understanding on issues and investigations in Statistics curriculum,
  Pedagogy and assessment
- Differentiate between significant research trends in Statistics Education
- Understand ethical issues in investigation in conducting statistical survey/research
- Appreciate need and scope of interdisciplinary research in Statistics Education
- Conduct small scale research in a potential research area of their choice
- Use appropriate statistical techniques to analyze the research data
- Make meaningful inferences based on the analysis of research data
- compile and write their dissertation based on their experiences as a researcher

7. CO – PO AND CO – PSO MAPPING OF COURSES

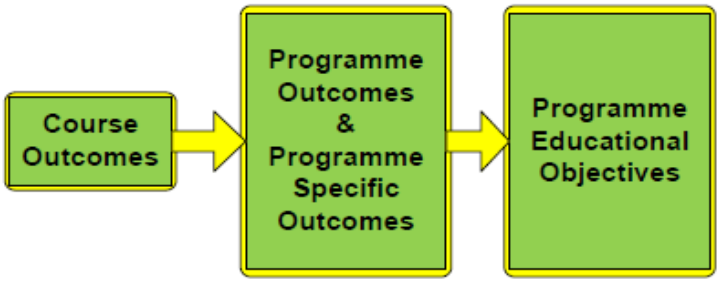
All the courses together must cover all the POs (and PSOs). For a course we map the COs to POs through the CO-PO matrix and to PSOs through the CO-PSO matrix as shown below. The various correlation levels are:

- "1" – Slight (Low) Correlation
- "2" – Moderate (Medium) Correlation
- "3" – Substantial (High) Correlation
- "-" indicates there is no correlation.

7.1 Levels of Outcomes

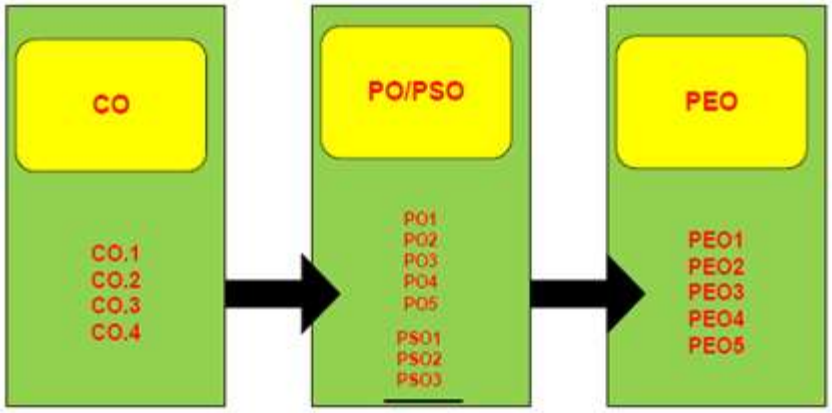
There are four levels of outcome such as Course Outcome (CO), Programme Outcome (PO), Program Specific Outcome (PSO) and Program Educational Objective (PEO).Course Outcomes are the statements that declare what students should be able to do at the end of a course. POs are defined by Accreditation Agencies of the country, which are the statements about the knowledge, skills and attitudes, graduate attributes of a formal engineering program should have Graduates Attributes (GAs) are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. GAs form a set of individually assessable outcomes of the programme. The NAAC laid down the graduate attributes relating to programme outcomes and is to be derived by programme. Figure 7.1 shows the building block of CO-PO&PSO-PEO relationship.

FIGURE 7.1: RELATING THE OUTCOMES (CO-PO and PSO-PEO)



After CO statements are developed by the course in-charge, CO will map with any possible PO's based on the relationship exist between them. But the PO's are not necessarily mapped with any one CO and it may be left blank. Anyhow, it is mandatory that all POs should be mapped with any one of PSO and PEO which are specified in the programme which is shown in Fig. 7.2.

FIGURE 7.2: RELATIONSHIP BETWEEN CO, PO & PSO and PEO



7.2 Process involved in CO-PO Mapping

The role of CO-PO mapping will be assigned to the faculty as per hierarchy. After the course (subject) allotment from the department, the course in-charge of the course has to write appropriate COs for their corresponding course. It should be narrower and measurable statements. By using the action verbs of learning levels, CO's will be designed. CO statements should describe what the students are expected to know and able to do at the end of each course, which are related to the skills, knowledge and behavior that students will acquire through the course.

7.3 Process used to identify the curricular gaps to the attainment of COs/POs

The process used to identify the curricular gaps to the attainment of COs/POs is explained as below:

Step-1: The course handling faculty, after CO-PO mapping, would submit CO attainment to Course coordinator.

Step-2: The course coordinator would submit the CO-PO attainment along with curriculum gap identified in the course and recommendations to conduct co-curricular activities &identify content beyond the syllabus to Year wise coordinator.

Step-3: The year wise coordinators who are the members of the PAC (Programme Assessment Committee) would consolidate the CO attainment of the respective year along with curricular gaps and recommendations to conduct co-curricular activities reported by course coordinators.

Step-4: The PAC would consolidate the CO and PO attainment of the programme with all the identified gaps and submit report to DAB (Department Advisory Board).Program Assessment Committee after getting prior approval from DAB about the steps to be taken to bridge the curricular Gap and content beyond the syllabus may be delivered to the students through teaching, arranging guest lectures, industrial visit, internship, quiz, etc.

8. COURSE OUTCOMES TO PO AND PSO MAPPING

Mapping strength of a course to PO/ PSO can be obtained by taking the average of the CO-PO/ PSO mapping matrices of that course.

8.1 Objective of the Course

The course aims to inculcate knowledge on theoretical and applied aspects of Statistics in a wider spectrum. It intends to impart awareness on the importance of Statistical concepts across diversified fields and to provide practical training on the applications of Statistical tools in carrying out data analysis using Statistical software like SAS, SYSTAT and SPSS and using the programming knowledge in R. The course curriculum is designed in such a way that the candidate on successful completion of the course will have ample opportunities to take up national level competitive examinations like CSIR NET in Mathematical Sciences, SET, Indian Statistical Service (ISS) of UPSC, etc.

8.2 Eligibility Criteria for Admission

A candidate who has acquired B.Sc. Degree in Statistics or B.Sc. Degree in Mathematics with Statistics or Mathematical Statistics as an Allied / Ancillary subject securing 45% of marks (40% in the case of SC/ST candidates) in aggregate in Part III shall be permitted to join the course, appear in the University Examinations and qualify for the award of M.Sc. (Statistics) degree after the course of study in the Department of Statistics at this University. Candidates who have acquired B. Sc. Degree in Statistics shall be given preference in the admission to this course.

8.3 Duration of the Course and Credits

The course of the degree of M.Sc. in Statistics shall consist of two academic years comprising four semesters. During the course of study, a set of Core, Elective and Supportive Papers and one add on Course MOOC (online) shall be offered. While practical papers shall be offered in all four semesters, Project / Dissertation work shall be carried out by the candidate during the fourth semester.

Table 8.1: Break - Up of Total Credits For the Course

Sl. No.	Subjects	Credits
1.	Core Papers – Theory	13×4 Credits = 52 Credits
2.	Core Papers – Practical	$\left.\begin{matrix}02\times3\text{Credits}\\02\times3\text{Credits}\end{matrix}\right\} = 12$ Credits
3.	Elective Papers	04×3 Credits = 12 Credits
4.	Project/Dissertation	01×8 Credits = 08 Credits
5.	Supportive Paper	02×3 Credits = 06 Credits
6.	Human Rights and Duties (No credit calculated)	-
7.	Add on Course MOOC(online)	-
	Total	**90 Credits**

The course of study shall be based on the pattern of Choice Based Credit System (CBCS) with continuous internal assessment and comprehensive external assessment. The comprehensive external assessment shall be done as the end semester University examination. The odd semester shall begin in July and the even semester shall begin in December. Each candidate shall earn a minimum of 90 credits during the period of study. The break-up of total credits for the course shall be as given Table 8.1.

8.4. Course Structure and Scheme of Examination

Candidates admitted to the course shall be examined in each paper under continuous internal assessment and end semester University examination. The maximum marks to each paper shall be fixed as 100. The maximum marks for continuous internal assessment and end semester University examination for theory papers shall be fixed as 25 and 75, respectively which are given in Table 8.2.

Table 8.2Course Structure and Scheme of Examination

Code	Title of the Subject	Examination				Credits
		Duration	CIA Marks	External Marks	Total Marks	
SEMESTER I						
18UPSTA1C01	Real and Complex Analysis	3	25	75	100	4
18UPSTA1C02	Measure and Probability Theory	3	25	75	100	4
18UPSTA1C03	Distribution Theory	3	25	75	100	4
18UPSTA1C04	Sampling Theory	3	25	75	100	4
	Elective I	3	25	75	100	3
18UPSTA1P01	Statistics Practical I	3	40	60	100	3
SEMESTER II						
18UPSTA2C05	Linear Algebra	3	25	75	100	4
18UPSTA2C06	Estimation Theory	3	25	75	100	4
18UPSTA2C07	Statistical Quality Control	3	25	75	100	4
	Elective II	3	25	75	100	3
	Supportive Paper I	3	25	75	100	3
18UPSTA2P02	Statistics Practical II	3	40	60	100	3
06PHR01	Human Rights and Duties (No credit calculated)	**(Course Offered by Department of Sociology at University Level)**				-
SEMESTER III						
18UPSTA3C08	Hypothesis Testing	3	25	75	100	4
18UPSTA3C09	Multivariate Analysis	3	25	75	100	4
18UPSTA3C10	Demographic Methods	3	25	75	100	4
18UPSTA3C11	Econometrics	3	25	75	100	4
	Elective III	3	25	75	100	3
	Supportive Paper II	3	25	75	100	3
18UPSTA3P03	Statistics Practical using R - I	3	40	60	100	3
SEMESTER IV						
18UPSTA4C12	Linear Models and Design of Experiments	3	25	75	100	4
18UPSTA4C13	Stochastic Processes	3	25	75	100	4
	Elective IV	3	25	75	100	3
18UPSTA4P04	Statistics Practical using R - II	3	40	60	100	3
18UPSTA4C14	Project/Dissertation with Viva-Voce	-	40	60	100	8
		Total	**675**	**1725**	**2400**	**90**

All the admitted candidates shall have to carry out a Project/Dissertation work during the fourth semester under the supervision of the faculty of the Department of Statistics in the University. Candidates shall have to prepare and submit a report of the Project/Dissertation work at the end of the fourth semester.

The project report/dissertation will be evaluated jointly by an External Examiner and the Internal Examiner (Project Guide) for a maximum of 40 marks. Each candidate shall appear for a Viva-Voce examination for a maximum of 20 marks, which will be conducted jointly by an External Examiner and the Internal Examiner (Project Guide). Project work maximum of 40 marks with 2 reviews each of 20 marks.

Sl. No.	Classifications	Marks
1.	Internal Marks for First Review	20
2.	Internal Marks for Second Review	20
3.	External Examiner and the Internal Examiner	40
4.	Viva-Voce Examination	20
	Total	**100**

8.5. List of Core, Elective and Supportive Papers

A total of 13 Core Theory Papers, 4 Core Practical Papers, 4 Elective Papers, 2 Supportive Papers, 1 Compulsory Paper (Human Rights and Duties) and 1 MOOC Online Course shall be offered by the Department of Statistics. The list of papers is given as below;

8.5.1: List of Core Papers – Theory

S. No.	Course Code	Title of the Course	Credits
1.	18UPSTA1C01	Real and Complex Analysis	4
2.	18UPSTA1C02	Measure and Probability Theory	4
3.	18UPSTA1C03	Distribution Theory	4
4.	18UPSTA1C04	Sampling Theory	4
5.	18UPSTA2C05	Linear Algebra	4
6.	18UPSTA2C06	Estimation Theory	4
7.	18UPSTA2C07	Statistical Quality Control	4
8.	18UPSTA3C08	Hypothesis Testing	4
9.	18UPSTA3C09	Multivariate Analysis	4
10.	18UPSTA3C10	Demographic Methods	4
11.	18UPSTA3C11	Econometrics	4
12.	18UPSTA4C12	Linear Models and Design of Experiments	4
13.	18UPSTA4C13	Stochastic Processes	4

8.5.2: List of Elective Courses

(*Note*: One paper is to be chosen from the list provided under Semester I, II, III and IV and is to offered in the respective semester)

S. No.	Course Code	Title of the Course	Credits
SEMESTER I / ELECTIVE I			
1.	18UPSTA1E01	Official Statistics	3
2.	18UPSTA1E02	Actuarial Statistics	3
3.	18UPSTA1E03	Data Mining	3
SEMESTER II / ELECTIVE II			
4.	18UPSTA2E04	Operations Research	3
5.	18UPSTA2E05	Simulation and Statistical Modeling	3
6.	18UPSTA2E06	Biostatistics	3
SEMESTER III / ELECTIVE III			
7.	18UPSTA3E07	Categorical Data Analysis	3
8.	18UPSTA3E08	Statistical Methods for Epidemiology	3
9.	18UPSTA3E09	Statistical Data Analysis using R	3
SEMESTER IV / ELECTIVE IV			
10.	18UPSTA4E10	Applied Regression Analysis	3
11.	18UPSTA4E11	Time Series Analysis	3
12.	18UPSTA4E12	Bayesian Methods	3

8.5.3: List of Supportive Papers

S. No.	Course Code	Title of the Course	Credits
Supportive Paper I / Semester II			
1.	18UPSTA2S01	Basic Statistical Methods	3
2.	18UPSTA2S02	Statistics for Behavioral Sciences	3
3.	18UPSTA2S03	Probability and Statistics for Scientists	3
4.	18UPSTA2S04	Statistics for Researchers	3
Supportive Paper II / Semester III			
1.	18UPSTA3S01	Descriptive Statistics	3
2.	18UPSTA3S02	Computer Oriented Statistical Methods	3
3.	18UPSTA3S03	Statistics for Economics	3
4.	18UPSTA3S04	Mathematical Economics	3

Compulsory Paper

S. No.	Course Code	Title of the Course	Credits
1.	06PHR01	Human Rights and Duties	2

Add On Course

S. No.	Course Code	Title of the Course	Credits
1.	-	MOOC Online Course	4

9. ASSESSMENT PROCESS

9.1 Assessment Process for CO Attainment

For the evaluation and assessment of CO's and PO's, rubrics are used. The rubrics considered here are given below:

9.1.1: CO Assessment Rubrics: Course Outcome is evaluated based on the performance of students in internal assessments and in university examination of a course. Internal assessment contributes 25% and university assessment contributes 75% to the total attainment of a CO.

9.1.2: CO Assessment Tools: The description of Assessment tools used for the evaluation of programme outcomes is given in Table 9.1. The various assessment tools used to evaluate CO's and the frequency with which the assessment processes are carried out are listed in table 9.2. In each course, the level of attainment of each CO is compared with the predefined targets, if is not the course coordinator takes necessary steps for the improvement to reach the target. With the help of CO against PO/PSO mapping, the PO/PSO attainment is calculated by the programme coordinator.

Table 9.1: Mapping of Assessment Tools to POs/PSOs with frequency

Mode of Assessment	Assessment Tool	Description	Evaluation of Course Outcomes	Related POs/PSOs	Frequency of Assessment
Direct	Theory Internal Examinations	Three written examinations are conducted and its average marks are considered.	The questions in the internal examinations and assignment sheets are mapped against COs of respective course. The questions for three internal examination and assignment are framed in such a way to cover all course outcomes. The final attainment for each CO under direct assessment is calculated by taking from average of the CO attainments Internal	PO1 to PO5	Two per Semester
Direct	Assignments	Three assignments are given for each course for continuous assessment. Average marks are considered.		PO1 to PO5	Continuous

			Examinations and Assignments.		
Direct	Day to day evaluation	The day to day evaluation is considered.	The final attainment for each CO is calculated by taking average of the % evaluation attainment from day to day and Internal Practical Examination. Three Internal practical exams are conducted and averages of these three assessments are considered.	PO1 to PO5	Continuous
Direct	Internal Practical Examination	Three internal practical examination is conducted		PO1 to PO5	Three practical exams in every semester
Direct	External Practical	One external practical examination is conducted	One external practical exam is conducted	PO1 to PO5	One per Semester
Direct	Project	To test student's concepts in design, creative thinking and independent analysis. Three project reviews are conducted.	Continuous assessment is carried by the Project review committee. First review emphasizes on Literature survey and problem identification, second review on.	PO1 to PO5	Two project reviews in Final Semester.
Direct	Comprehensive Viva Voce Examination	To assess the student's analytical skills in the domain.	The assessment is carried out by HOD and External Examiner and Faculty Guide along with student's overall academic performance.	PO1 to PO5	IV Semester of PG Programme
Indirect	Alumni Survey	This survey gives the	At the end of the programme	PO1 to PO5	At the end of each course

		opinion of the student on the attainment of course outcomes.	Alumni survey is collected from Alumni a considered for the PO attainment under Indirect assessment.		
Indirect	Exit Survey	This survey gives the opinion of the graduate on the attainment of PO"s.	At the end of the programme, graduate exit survey is collected from the graduates and considered for the PO under attainment indirect assessment.	PO1 to PO5	At the end of the programme

Table 9.2: Attainment Levels of Cos

Assessment Methods	**Attainment Levels**	
Internal Assessment	Level 1	60% of students scoring more than 40% marks in internal assessment tools
	Level 2	70% of students scoring more than 40% marks in internal assessment tools
	Level 3	75% of students scoring more than 40% marks in internal assessment tools
University Assessment	Level 1	60% of students scoring more than 40% marks in internal assessment tools
	Level 2	70% of students scoring more than 40% marks in internal assessment tools
	Level 3	75% of students scoring more than 40% marks in internal assessment tools

9.4 Quality/Relevance of Assessment Process Theory

Tests, assignments, seminars and attendance shall be the components for continuous internal assessment. There shall be three tests, three assignments and one seminar for each paper. The pattern of question paper for tests, the problems for assignments and the topics for seminars shall be at the discretion of the course teacher. The average of **best two** tests for a maximum of 10 marks, the average of all the

assignments for a maximum of 5 marks, the actual marks secured by the candidate in the seminar for a maximum of 5 marks and the actual marks secured by the candidate for a maximum of 5 marks for attendance shall be taken for calculating the continuous internal assessment marks for a paper.

Internal mid Tests: Internal tests serve to encourage students to keep up with course content covered in class. Three written examinations are conducted and its average marks are considered. For theory subjects, during a semester there shall be 3 mid-term examinations. Each mid- term examination consists of multiple choice questions and higher order thinking questions. The test is conducted for 50 marks in each cycle. A maximum of 25 marks shall be allotted under continuous internal assessment in each theory paper offered by the Department. The distribution of theory papers marks is as given under:

Sl. No	Classifications	Marks
1.	Marks for Internal Tests	10
2.	Marks for Assignments	05
3.	Marks for Seminars	05
4.	Marks for Attendance	05
	Total	**25**

The maximum marks for continuous internal assessment and end semester University examination for practical papers shall be fixed as 40 and 60, respectively. The distribution of continuous internal assessment marks for each core - practical paper is as given below:

Sl. No	Classifications	Marks
1.	Marks for Internal Tests	10
2.	Marks for Record	25
3.	Marks for Attendance	05
	Total	**40**

The questions in the internal examinations and assignment sheets are mapped against COs of respective course. The questions for two internal examinations and Assignments are framed in such a way to cover all Course Outcomes. First Assignment should be submitted before the conduct of the second mid-examination. The total marks secured by the student in each mid-term examination are evaluated for 50 marks, and the average of the three mid-term examinations shall be taken as the final marks secured by each candidate. The questions in the internal examinations and assignment sheets are mapped against COs of respective course. The questions for three internal examinations and Assignments are framed in such a way to cover all Course Outcomes.

9.4.1 Practical Subjects

Practical classes with hands-on training in the core course concepts and the opportunity to explore methods used in their discipline. All the students are expected to be regular and learn the practical aspects of the subject and develop the necessary skills to become professionals. In order to facilitate interaction among the students and to develop team spirit, the students are expected to carry out experiments in

groups. Performance assessment is based on the ability of the student to actively participate in the successful conduct of prescribed practical work and draw appropriate conclusions. The student submits a record of practical work performed in each practical class.

9.4.2 University Examination

The end semester examination shall be conducted with an internal supervisor/faculty incharge. The end-semester examinations are of 3 - hour duration and cover the entire syllabus of the course. It would generally satisfy all course outcomes for a particular course. The COs is evaluated based on the set attainment levels. The distribution shall be 25 marks for internal evaluation (5 marks for attendance, 5 marks for seminar, 5 marks for assignment and 10 marks for internal tests) and 75 marks for end semester examination. There shall be three internal tests in a Semester and the average of the three shall be considered for the award of marks for internal tests.

9.4.3 Major Project

Major Project is intended to be a challenge to the intellectual and innovative abilities of students. It gives students the opportunity to synthesize and apply the knowledge and analytical skills learned in the different disciplines. Out of a total of 100 marks for the project work, 40 marks shall be allotted for Internal Evaluation and 60 marks for the End Semester Examination (Viva-Voce).

The Internal (review): Evaluation shall be on the basis of two reviews given by each student on the topic of her project. Project will enable student to think innovatively in the field of Statistics. Students are expected to perform an indepth study of the topic assigned in light of the preliminary report prepared in the third semester. Review and finalize the approach to the problem. Perform detailed analysis/ modeling/ simulation/ design/ problem solving experiment as needed. Develop a final report and arrive at results &conclusions and suggest future directions. Prepare a paper for Conference presentation/ publication, if possible. Prepare a report in the standard format for being evaluated by the Internal project Review Committee.

Process for Assessing the Quality of Projects (final evaluation of project): The Internal project Review Committee and the project guide together will analyze the nature of the project and make sure that the work is environment friendly, ensures safety, ethics and cost effective. The projects are classified into different streams and their relevance to PO's and PSO's are identified to ensure its quality.

9.4.5 AWARD OF DEGREE

A candidate who secures a minimum of 50% of marks in the end semester University examination and also a minimum of 50% of marks in aggregate comprising both continuous internal assessment and end semester University examination in each paper shall be declared to have passed the M.Sc. degree course in Statistics.

A candidate who secures a minimum of 75% of marks in aggregate comprising both continuous internal assessment and end semester University examination shall be declared to have passed the examination in FIRST CLASS WITH DISTINCTION, if the candidate has passed all the examination prescribed for the course in the first appearance.

A candidate who secures a minimum of 60% of marks comprising both continuous internal assessment and end semester University examination in aggregate shall be declared to have passed the examination in FIRST CLASS.

A candidate who has passed in all the papers prescribed for the course in the FIRST APPEARANCE shall be eligible for Ranking/Distinction.

9.4.6 PROJECT AND DISSERTATION

(a) Topic: The topic of the dissertation/project work shall be assigned to the candidate at the beginning of third semester and a copy of the same shall be submitted to the University for Approval.

(b) Number of Copies: Candidates shall prepare the dissertation / project report and submit three copies of the same for evaluation by the examiners. One copy shall be retained in the University library, one copy shall be placed in the Department library and the other one shall be given to the candidate after evaluation.

(c) Format for the Preparation of Dissertation / Project Report

- Title page
- Bonafide Certificate
- Acknowledgement
- Table of contents

Model Format of the Title Page

TITLE OF THE PRJOCET / DISSERTATION

Project/Dissertation Submitted in partial fulfilment of the requirement for the award of the Degree of

Master of Science in
STATISTICS
(Under Choice Based Credit System)

to the Periyar University, Periyar Palkalai Nagar, Salem – 636 011
by
Students Name
Register Number
Department
Year

Model Format of the Certificate

Certificate

This is to certify that the dissertation / project work entitled '.....' submitted in partial fulfilment of the requirement for the award of the Degree of Master of Science in **STATISTICS (Under Choice Based Credit System)** to the Periyar University, Periyar Palkalai Nagar, Salem is a record of bonafide research work carried out by him / her under my supervision and guidance and that no part of the dissertation/project work has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date:
Place: Signature of the Guide
Counter signed:

Signature of the Head of the Department

Model Table of Contents

Chapter No.	Title	Page No.
I	Introduction	
II	Review of Literature	
III	Results	
IV	Summary	
V	References	

9.5 Pattern of Question Paper for the End Semester Comprehensive Examination

The question paper shall consist of three sections. While there shall be no choice in Part A, Open choice in Part B and internal choice (either or type) shall be given in Part C. In Part A, there shall be four objective type questions from each of the five units. In Part B there shall be eight questions from each of the five units and Part C, there shall be one question with internal choice (either/or type) from each of the five units.

Part A - (20 x 1 = 20 marks) (four questions from each units)
Part B - (3 x 5 = 15 marks) (Answer any three questions out of five questions)
Part C – (5 x 8 = 40 marks) (one question from each unit with internal choice)

M.Sc., Degree Examination
Branch – Statistics

SUBJECT

Time: 3 Hours Max. Marks: 75

Part - A (20×1 =20 Marks)

Answer *ALL* questions

Each objective type question carries *One* mark

1. from Unit I
2. from Unit I
3. from Unit I
4. from Unit I
5. from Unit II
6. from Unit II
7. from Unit II
8. from Unit II
9. from Unit III
10. from Unit III
11. from Unit III
12. from Unit III
13. from Unit IV
14. from Unit IV
15. from Unit IV
16. from Unit IV
17. from Unit V
18. from Unit V
19. from Unit V
20. from Unit V

Part - B (3 × 5 = 15 Marks)

Answer any *Three* questions

Each question carries *Five*marks

21. from Unit I
22. from Unit II
23. from Unit III
24. from Unit IV
25. from Unit V

Part – C (5 × 8 = 40 marks)

Answer *ALL* questions

Each question carries *EIGHT* marks

26. (a) from Unit I

(OR)

(b) from Unit I

27. (a) from Unit II

(OR)

(b) from Unit II

28. (a) from Unit III

(OR)

(b) from Unit III

29. (a) from Unit IV

(OR)

(b) from Unit IV

30. (a) from Unit V

(OR)

(b) from Unit V

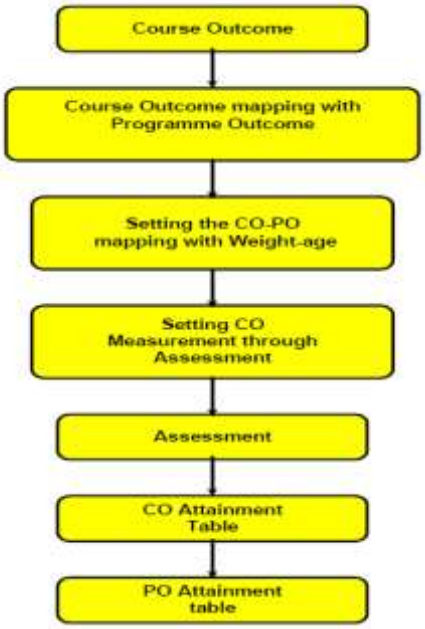
10. ATTAINMENT LEVELS

Course outcomes of all courses are assessed with the help of above mentioned assessment tools and attainment level is evaluated based on set attainment rubrics as per table 9.2. If the average attainment of a particular course for two consecutive years is greater than 80% of the maximum attainment value (i.e. 80% of 3 = 2.4), then for that particular course the current rubrics for attainment must be changed to analyses continuous improvement.

Validation of CO-PO mapping the process of CO-PO mapping validation is given in figure 9.1 and is explained as below:

Step 1: Obtain course outcome.
Step 2: Mapping of course outcome with program outcome.
Step 3: Setting weightage for CO assessment.
Step 4: CO measurement through assessment.
Step 5: Obtain CO attainment table through direct and indirect assessment methods.
Step 6: Obtain PO attainment table through direct and indirect assessment methods.

Fig. 9.2 Validation of CO-PO mapping



10.1 Assessment and Attainment Methods

Assessment is one or more processes which is carried out by the institution, that identify, collect and prepare data to evaluate the achievement of course outcomes and program outcomes. Attainment is the action or fact of achieving a standard result towards accomplishment of desired goals. Primarily attainment is the standard of academic attainment as observed by test and/or examination result. Assessment methods are categorized into two as direct method and indirect method to access CO's and PO's. The direct methods display the student's knowledge and skills from their performance in the continuous internal assessment tests, semester examinations and supporting activities such as seminars, workshop etc., and these methods provide a sampling of what students know and/or can do and provide strong evidence of student learning. The indirect method done through surveys and interviews, it asks the stakeholders to reflect their views on student's learning. The institute assesses opinions or thoughts about graduate's knowledge or skills by different stakeholders.

CO assessment methods are employed direct assessment method and indirect assessment method is considered for 80% and 20% weightages respectively. Internal test assessment and end semester examination assessment are considered with the weightage of 20% and 80% respectively for the direct assessment of CO.

10.2 Procedure for Attainment of Program Outcomes

At the end of the each programme, the PO/PSO assessment is done from the CO attainment of all curriculum components. As per guidelines, program can appropriately define the attainment level. The attainment level may be set by the particular program or commonly by the University. The attainment can be made as best the choice by the University or the program by analyzing the student's knowledge. This can be achieved by using different supporting activities. This attainment is mainly for the purpose of making a statistician with good analytical, practical and theoretical knowledge about the program by attaining the PEO's and PSO's of the program and the University. For the evaluation and assessment of CO's and PO's, rubrics are used.

11. ASSESSMENT PROCESS FOR OVERALL PO AND PSO ATTAINMENT

11.1 PO and PSO Assessment Process

PO/PSO assessment is done by giving 75% weightage to direct assessment and 25% weightage to indirect assessment. Direct assessment is based on CO attainment, where 75% weightage is given to attainment through University examinations and 25% weightage is given to attainment through internal assessments. Indirect assessment is done through Graduate exit survey and alumni survey where Graduate exit survey and alumni survey is given a weightage of 50% each.

11.2 PO and PSO Assessment Tools

The various direct and indirect assessment tools used to evaluate POs& PSOs and the frequency with which the assessment processes are carried out are listed in table 11.1.

Table 11.1: Assessment tools used for evaluation of PO and PSO Attainment

<table>
<tr><th colspan="5">PO, PSO ASSESSMENT TOOLS</th></tr>
<tr><td rowspan="15">Direct (75% weightage)</td><td rowspan="15">CO Assessment</td><td>Course Type</td><td colspan="2">Assessment Tools</td><td>Minimum Frequency</td></tr>
<tr><td rowspan="4">Theory</td><td rowspan="3">Internal evaluation</td><td>Internal Tests</td><td>Thrice per course</td></tr>
<tr><td>Assignments</td><td rowspan="2">Twice per course</td></tr>
<tr><td>Seminars</td></tr>
<tr><td>Attendance</td><td>Once per course</td></tr>
<tr><td colspan="2">University Exam</td><td>Once per course</td></tr>
<tr><td rowspan="3">practical</td><td rowspan="3">Internal Evaluation</td><td>Internal</td><td>Thrice per course</td></tr>
<tr><td>Record</td><td>Once per course</td></tr>
<tr><td>Attendance</td><td>Once per course</td></tr>
<tr><td colspan="2">University Exam</td><td>Once per course</td></tr>
<tr><td rowspan="3">English Communication skills</td><td rowspan="3">Internal Evaluation</td><td>Group Discussion</td><td>Once per course</td></tr>
<tr><td>Presentation Skill</td><td>Once per course</td></tr>
<tr><td>Writing skill</td><td>Once per course</td></tr>
<tr><td colspan="2">University Exam</td><td>Once per course</td></tr>
<tr><td rowspan="2">Mini project</td><td colspan="2">Internal Evaluation-Reviews</td><td>Once per course</td></tr>
<tr><td colspan="2">University Viva voice</td><td>Once per course</td></tr>
<tr><td>Comprehensive Viva</td><td colspan="2">Internal Evaluation</td><td>Once per course</td></tr>
<tr><td>Seminar</td><td colspan="2">Presentation</td><td>Once per</td></tr>
</table>

				course
		Major Project	Seminars	Twice per course
			External Viva voce	Once per
			Report	Once per
Indirect 20% Weightage	**Surveys**	Graduate Exit Survey		At the end of the Program
		Alumni Survey		Once per year

11.3 Quality / relevance of assessment tools and processes:
(i) Direct Assessment Tools and Process
Direct assessment tools described in section 9.1 are used for the direct assessment of POs and PSOs. Initially, the attainment of each course outcome is determined using internal as well as external (university exam) assessment as described in section 7.2. The each PO attainment of corresponding to a particular course is determined from the attainment values obtained for each course outcome related to that PO and the CO-PO mapping values. Similarly, the values of PSO attainment are also determined.

11.4 Indirect Assessment Tools and Process
Indirect assessment is done through program exit survey, alumni survey and employer survey where program exit survey and employer survey are given a weightage of 25% each and alumni survey is given a weightage of 50%.

11.4.1 Graduate Exit Survey
A exit survey is conducted for students who have graduated out of the department for that year. Relevant questionnaire in exit survey form to evaluate attainment of POs and PSOs is given in section (a) and relation of POs & PSOs with questionnaire is given in section (b).

11.4.2 Questionnaire Format
Kindly rate the following criteria on a scale of 1-5. Your genuine response will be helpful for the continuous quality improvement of our PG programme in Statistics.

5. Excellent
4. Very Good
3. Good
2. Average
1. Poor

S. No.	Criteria	Rating
1.	Opinion about PG Programme in Statistics	
2.	Ability acquired to apply knowledge of mathematics and Statistics	
3.	Competence developed to analysis interprets data and design complex computing system or process specific needs.	
4.	Skill gained to apply modern Statistics tools and techniques for Statistics practice.	
5.	Responsibilities level acquired develop Statistical solutions for sustainable development ethically and economically.	
6.	Leadership quality and team sprit inculcated through various student development Programmes	
7.	Zeal to engage in, to resolve contemporary issues and acquire lifelong learning.	

11.4.3 Evaluation Process

The questionnaire consists of 7 questions which is relevant for assessing each PO and PSO. Each question is having 5 options namely Excellent, Very Good, Good, Average and Poor, which is given marks 5, 4, 3, 2, 1 respectively. These survey results are tabulated and the average values corresponding to each PO and PSO are determined.

11.5 Alumni Survey

Feedback is taken from alumni. Relevant questionnaire in alumni survey form to evaluate attainment of POs and PSOs is given in section (i) and relation of POs &PSOs with questionnaire is given in section (11.4.2).

(i) Questionnaire Format

Kindly rate the following criteria on a scale of 1-5. Your genuine response will be helpful forthe continuous quality improvement of our PG programme in Statistics

5. Excellent
4. Very Good
3. Good
2. Average
1. Poor

S.No	Criteria	Rating
1	Extent of curriculum meeting the industry needs.	
2	Your ability to apply knowledge and design electronic system or process to meet desired specifications and needs.	
3	Benefit from value added certifications, workshops and training programmes conducted during your course.	
4	Your ability to use techniques, skills and modern engineering tools necessary for engineering practice.	
5	Benefit from communication skills, presentation skills and leadership qualities gained from the co-curricular and extracurricular activities.	
6	Your ability to engage in, to resolve contemporary issues and acquire lifelong learning.	
7	Competence to function on multidisciplinary teams	
8	Skills attained to create, select and apply appropriate techniques, resources and modern engineering and IT tools.	
9	Extent of Ethical, social and environmental values inculcated, helping you to relate Electronics and Communication engineering issues with societal needs.	

(ii) Evaluation Process: The questionnaire consists of 9 questions which is relevant for assessing each PO and PSO. Each question is having 5 options namely Excellent, Very Good, Good, Average and Poor, which is given Marks 5, 4, 3, 2, 1 respectively. These marks are tabulated and the average values corresponding to each PO and PSO are determined.

11.5.1 The attainment of the PEOs Table 11.3: PEO Evaluation Criteria

S.No	Name of the Evaluation Criterion	Weightages in %
Direct Assessment (80%)		
1.	Direct Evaluation of Program Outcomes (POs) of the concerned PEO	60
2.	Placements	15
3.	Higher Studies	5
Indirect Assessment (20%)		
4.	Graduate Exit Survey	10
5.	Alumni Survey	10
Total		100

SEMESTER I

AIMS

1. To provide a broad based high quality education with a combination of the subjects like Real and complex Analysis, Measure and Probability Theory, Distribution Theory, Sampling Theory, Official Statistics, Data mining and Actuarial Statistics to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability and confidence to analyse and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
3. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in Statistical computation.

SEMESTER 1.1: REAL AND COMPLEX ANALYSIS

Semester	**I**
Paper code	**18UPSTA1C01**
Paper title	**Real and Complex Analysis**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:

1. To understand the basic topology of a real analysis valued function and results.
2. To understand and develop manipulation skills in the use of Bolzano Weierstrass theorem.
3. To understand certain theorems like mean value theorem.
4. To understand and learn to use Convergent Sequences – Subsequence's and Cauchy Sequences.
5. To understand certain theorems like the L' Hospital's Rule - Taylor's theorem.
6. To study the functions with positive real part.
7. To understand Rieman - Stieljtes (R-S) integral of Integration and Differentiation.

8. To understand the Integration of vector – Valued functions – Uniform Convergence of Continuity and Integration and Differentiation – Stone – Weierstrass – Theorem.
9. To understand the concept of complex analysis of Analytic functions, Cauchy - Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula.

Course outcomes

Upon successful completion, students will have the knowledge and skills to

- ✓ The fundamental concepts of real and complex analysis and their role in modern mathematics and applied contexts.
- ✓ Demonstrate accurate and efficient use of real and complex analysis techniques Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from real and complex analysis.
- ✓ Apply problem-solving using real and complex analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts.

Unit I

Basic Topology – Finite, Countable and Uncountable Sets - Definition – Theorem and Examples - Metric Spaces – Compact Sets – Bolzano Weierstrass theorem – Perfect Sets – Connected Sets - Theorem and examples.

Unit II

Numerical Sequence and Series – Convergent Sequences – Subsequence's and Cauchy Sequences – Upper and Lower Limits – Special Sequences - Series - Series of nonnegative terms – Root and Ratio Tests – Power Series – Absolute Convergence – Addition and Multiplication of Series – Definition – Theorem and Examples.

Unit III

Continuity – Limits of functions – Continuous functions - Continuity of Compactness and Connectedness – Discontinuity – Monotonic Functions – Infinite – Real functions – Mean Value Theorem – Continuity of derivatives – L' Hospital's Rule - Taylor's theorem – Differentiation of vector valued functions.

Unit IV

Rieman - Stieljtes (R-S) integral – Properties – Integration and Differentiation – Integration of vector – Valued functions – Uniform Convergence of Continuity and Integration and Differentiation – Stone – Weierstrass – Theorem and Examples.

Unit V: Complex Analysis: Complex Analysis: Algebra of complex numbers, the complex plane, polynomials, power series. Analytic functions, Cauchy - Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula.

Books for Study

1. Walter Rudin, (2016), Principles of Mathematical Analysis, Fourteen reprints McGraw-Hill, New Delhi.
2. Sharma J. N, (2014), Functions of a Complex Variable, Forty Ninth Edition, Krishna Prakashan Media (P) Ltd, India.

Books for Reference

1. Arora, S, (1988), Real Analysis, SatyaPrakashanMandir, New Delhi.
2. Apostol, T. M, (1986), Mathematical Analysis, Second Edition, AddisonWesley, New York (Twentieth Reprint, 2002).
3. Ajit Kumar and Kumaresan, S, (2014), A Basic Course in Real Analysis, Chapman and Hall/CRC Press.
4. Bartle, R. G., and Sherbert, D. R, (2000), Introduction to Real Analysis, Third Edition, John Wiley & Sons, New York.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1C01**
Title of the Paper		**Real and Complex Analysis**
Unit Number	**Number of Hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
	60	75
Maximum marks for the paper		75

SEMESTER 1.2: MEASURE AND PROBABILITY THEORY

Semester	**I**
Paper code	**18UPSTA1C02**
Paper title	**Measure and Probability Theory**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:

1. To gain understanding of the abstract measure theory and definition and main properties of the integral. To construct Lebesgue's measure on the real line and in *n*-dimensional Euclidean space. To explain the basic advanced directions of the theory.
2. Students acquire basic knowledge of measure theory needed to understand probability theory, statistics and functional analysis.
3. The course provides a broad introduction to probability theory and random processes, with a specific focus on tools that are useful in electrical engineering disciplines. It is intended for both master and doctoral students interested in the many engineering applications in the field, and also for those interested in more

theoretical aspects, which are often needed to understand scientific papers and to produce research results.

4. Students obtain in this course a rigorous introduction to probability theory (with limited exposure to measure theory) and also an introduction to the most important random processes, with many engineering relevant examples. The course also offers the possibility to practice mathematical writing.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Application: measure theory is a part of the basic curriculum since it is crucial for understanding the theoretical basis of probability and statistics.
- ✓ Reflection: understanding of the theory on the basis of examples of application.
- ✓ Understand why a more sophisticated theory of integration and measure is needed;
- ✓ Show that certain functions are measurable;
- ✓ Construct the Lebesgue's integral;
- ✓ Understand properties of the Lebesgue's integral;
- ✓ Develop probabilistic concepts (random variables, expectation and limits) within the framework of measure theory.

Unit I :

Classes of sets - ring - field - σ-field - minimal σ-field - Borel field - sequences of sets - limit inferior and limit superior of sequences of sets - Measurable space - measure space – properties of measure - Lebesgue measure and Lebesgue- Stieltjes measure - Probability space - probability measure – properties of probability measure.

Unit II:

Measurable function – Random variable – discrete and continuous random variables - Distribution function – Properties – Decomposition of distribution functions - Expectation and moments – properties – moment generating functions – moments inequalities (Basic, Chebyshev's, Markov's, Holder's, Jensen's and Minkowski's inequalities) - Conditional probability and conditional expectation – properties and applications.

Unit III:

Modes of convergence – convergence in probability, convergence in distribution, convergence in *r*th mean, almost sure convergence and their inter relationships. Weak and complete convergences of distribution functions – Helly's first and second limit theorems (statement only).

Unit IV:

Characteristic Function: Definition and Properties - Uniqueness Theorem - Inversion Formula – Problems - Khintchine - Bochner's theorem (statement only) - Independence of random variables – Borel-Cantelli lemma – Borel 0-1 law, Kolmogorov's 0-1 law - Kolmogorov's inequality – Glivenko-Cantelli theorem (statement only).

Unit V:

Law of large numbers: Bernoulli's and Khintchine's weak law of large numbers, Kolmogorov's strong law of large numbers - Simple problems - Central limit theorems: De Moivre-Laplace central limit theorem, Lindeberg-Levy's central limit theorem,

Liaponov's central limit theorem – Lindeberg-Feller's central limit theorem (statement only) - Applications.

Books for Study

1. Bhat B. R, (2014), Modern Probability Theory (Fourth Edition), New Age International, New Delhi (Reprint 2015).

Books for Reference

1. Ash, B.R, (1972), Real Analysis and Probability, AcademicPress, New York.
2. Billingsley P, (2012), Probability and Measure (Third Edition), John Wiley & Sons, New York.
3. Chow, Y.S. and Teicher, H, (2012), Probability Theory;Independence, Interchange ability, Martingales (Second Edition). Springer Limited.
4. Feller, W. (2008), An Introduction to Probability Theory and its Applications, Volume I (Third Edition), John Wiley &Sons, New York.
5. Feller, W. (1972), An Introduction to Probability Theory and its Applications, Volume II, John Wiley & Sons, New York. (Reprint, 2008).
6. Loe've, M. (1978), Probability Theory (Fourth Edition), Springer-Verlag, New York. Rana, I.K. (2005), An Introduction to Measure and Integration (Second Edition), Morgan & Claypool.
7. Rohatgi, V.K. and Saleh, A.K.Md.E. (2011), An Introduction to Probability and Statistics (Second Edition). John Wiley & Sons, New York.
8. Ross, S.M (2010). A First Course in Probability. Pearson Prentice Hall.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1C02**
Title of the paper		**Measure and Probability Theory**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.3: DISTRIBUTION THEORY

Semester	**I**
Paper code	**18UPSTA1C03**
Paper title	**Distribution Theory**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:
1. Identify possible values for each random variable.
2. Identify how changing values for a parameter affects the characteristics of the distribution.
3. Identify the mean and variance for each distribution.
4. Match a histogram of sample data to plausible distributions.
5. Create a mixture of distributions and compare the shape, mean, and variance to a similar distribution that is not a mixture.

Course outcomes

After successfully completing the course, a student should be able to demonstrate…
- ✓ Calculate moments and generating functions
- ✓ Determine and interpret independence and conditional distributions
- ✓ Construct z, chi-squared, t and F tests and the corresponding confidence intervals from sample means and sample variances
- ✓ Apply chi-squared tests for contingency tables and goodness of fit
- ✓ Use generating functions to determine distribution function and moments

Unit I: Basic Distribution theory:
Basic distribution theory – Joint, marginal and conditional probability mass functions and probability density functions.Standard distributions for Binomial, Poisson, multinomial and Normal probability distributions.Bivariate normal distribution – Properties and relationships.

Unit II: Functions and Distribution:
Functions of random variables and their distributions – Methods of finding distributions: Cumulative Distribution Function - Jacobian transformation - Mathematical Expectation and Conditional expectation - Moment Generating Function - Characteristic Function.

Unit III: Types of Distributions:
Geometric, Hyper geometric, Negative Binomial, Truncation and its distribution (Binomial and Poisson), Power series and logarithmic distributions – Properties and relationships

Unit IV: Distributions and its Properties:
Exponential, Laplace, logistic, log-normal, beta, gamma, Cauchy and compound Poisson distribution - Sampling distributions - Central-t, Central-F, Central chi-square distributions – Properties and relationships.

Unit V: Order Statistics:
Non – central t - non–central chi-square - non-central F distributions and their properties. Order statistics: Distribution of r^{th} order statistics – Joint distribution of two or more order statistics - Distribution of sample range and median.

Books for Study

1. Bhuyan, K. C (2010), Probability Distribution Theory and Statistical Inference, New Central Book agency private ltd, Reprint, 2015
2. Mood, A.M., Graybill, F.A., and Boes, D.C, (1974), Introduction to the Theory of Statistics, Third Edition, McGraw-Hill International Edition

Books for Reference

1. Dudewicz, E.J., and Mishra, S. N. (1988). Modern Mathematical Statistics, John Wiley & Sons, New York.
2. Johnson, N. L., Kemp, A.W., and Kotz, S. (2005). Univariate Discrete Distributions, Third Edition, John Wiley and Sons, New York.
3. Johnson, N. L., Kotz, S., and Balakrishnan, N. (2004). Continuous Univariate Distributions.Vol.I, John Wiley and Sons (Asia), Singapore. 4. Rao, C. R. (2009). Linear Statistical Inference and Its Applications, Second Edition, John Wiley and Sons, New York.
5. Karian, Z.A., and Dudewicz, E.J. (2011). Handbook of Fitting Statistical Distributions with R, Chapman and Hall.
6. Mukhopadhyay, P, (2002), Mathematical Statistics, Book and AlliedPublishers, New Delhi.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1C03**
Title of the paper		**Distribution Theory**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.4: SAMPLING THEORY

Semester	**I**
Paper code	**18UPSTA1C04**
Paper title	**Sampling theory**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:

1. Identify the circumstances that make sampling unnecessary and the reason they are rare.
2. Identify the relation between the desired sample, the obtained sample, the sampling frame, and sample quality.
3. Define and distinguish probability and non-probability sampling.
4. Define the major types of probability sampling method and indicate when each is preferred.
5. Explain when non-probability sampling methods may be preferred.
6. Describe the concept of sampling error and explain how its size is affected by the number of cases sampled, the heterogeneity of the population, and the fraction of population included in the sample.

Course outcomes

Students who successfully complete the course should:

- ✓ Understand the principles underlying sampling as a means of making inferences about a population ,
- ✓ Understand the difference between randomization theory and model based analysis,
- ✓ Understand the concepts of bias and sampling variability and strategies for reducing these.,
- ✓ Be able to analyse data from multi-stage surveys,
- ✓ Have an appreciation of the practical issues arising in sampling studies.

Unit I: Sampling Techniques

Population and Sample – Census and sample survey – sampling – sampling unit, sampling frame, sampling distribution, standard error, questionnaire and schedule, sampling design – sampling and non-sampling errors – non-response and its effects – sample surveys – principles of sample survey - principal steps in sample survey - limitations of sampling – NSSO/CSO in India.

Unit II: Simple Random Sampling

Simple Random Sampling (without replacement): Notations and terminology- Estimates of population total, mean and their variances and standard errors - determination of sample size - pooling of estimates – confidence limits – simple random sampling of attributes – interpenetrating sub-samples.

Unit III: Stratified Random Sampling

Stratified random sampling: Estimates of population total, mean and their variances - Related properties – Allocation of sample sizes – Neyman's proportional and optimum allocations - Comparison of stratified sampling with simple random sampling - Estimation of proportion under stratified random sampling.

Unit IV: Systematic Sampling

Systematic sampling: Estimates of population total, mean, and their variances and standard errors – systematic sampling with linear trend – comparison of systematic sampling with stratified and simple random sampling – circular systematic sampling – Multi Stage sampling - cluster sampling.

Unit V: Varying Probability Sampling

Varying Probability Sampling: PPS sampling (without replacement) – gain due to PPS sampling – stratified PPS – selection procedures – Desraj, Horwitz – Thompson estimates. Ratio Estimate – Methods of estimation, approximate variance of the Ratio Estimate - Regression Estimators – Difference Estimators, Regression Estimators in Stratified Sampling - Double sampling.

Books for Study

1. Cochran, W.G, (2007), Sampling Techniques, Third Edition, John Wiley & Sons, New Delhi.
2. Singh, D and Choudhary, F.S, (1977), Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd, New Delhi. (Reprint 1986).

Books for Reference

1. Ardilly P and Yves T, (2006), Sampling Methods: Exercise and Solutions. Springer.
2. Desraj, (1976), Sampling Theory, Tata McGraw Hill, New York. (Reprint 1979).
3. Murthy, M. N, (1977), Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
4. Sukhatme P.V., and Sukhatme, B.V, (1970), Sampling Theory Surveys with Applications, Second Edition, Iowa State University Press.
5. Sukhatme, P.V., and Sukhatme, B.V, (1958), Sampling Theory Surveys with Applications. Indian Society of Agricultural Statistics, New Delhi.
6. Thompson, S.K, (2012), Sampling, John Wiley and Sons, New York.
7. Sampath S (2001), Sampling Theory and Methods, The new age international ltd. New Delhi.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1C04**
Title of the paper		**Sampling Theory**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 1.5.1: OFFICIAL STATISTICS

Semester	**I**
Paper code	**18UPSTA1E01**
Paper title	**Official Statistics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

After finishing this chapter, you should be able to:

1. Understanding the functioning of official statistics.
2. Students will become familiar with institutional, legal and organizational bases, and principles of functioning in official statistics.
3. They will understand the fundamentals of measurement in official statistics.
4. To overcome the limitations that arises from measurement and processes of statistical production.
5. Learn the methodological bases of measurement in official statistics.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ The Key aspects of official Statistics, as distinct from other branches of statistics.
- ✓ The legal and ethical constraints on organisations producing official statistics.
- ✓ The principal methods for data collection, analysis and interpretation of health, social and economic.
- ✓ The methods for presenting and preparing commentaries on official statistics.
- ✓ Data including spatial data.

Unit I: Introduction to NSSO, ISS and SSO:

Introduction to Indian and International statistical systems - Role, function and activities of Central and State Statistical Organizations - Organization of large scale

sample surveys - Role of National Sample Survey Organization - General and special data dissemination systems.

Unit II: Census of India and other countries:
Population growth in developed and developing countries - Evaluation of performance of family welfare programmes - Projections of labour force and manpower - Scope and content of population census of India.

Unit III: Agricultural and Economic Statistics:
System of collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects.

Unit IV: Educational and other Social statistics:
Statistics related to industries - Foreign trade - Balance of payment - Cost of living – Inflation - Educational and other social statistics.

Unit V: Indian official statistics:
Indian official statistics : Present official statistical system in India - Methods of collection of official statistics, their reliability and limitations - Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance - Various official agencies responsible for data collection and their main functions.

Books for Reference

1. Basic Statistics Relating to the Indian Economy (CSO) 1990.
2. Family Welfare Yearbook. Annual Publication of D/o Family Welfare.
3. Guide to Official Statistics (CSO) 1999.
4. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Government Publications.
5. Panse, V. G., Estimation of Crop Yields (FAO).
6. Principles and accommodation of National Population Censuses, UNESCO.
7. Statistical System in India (CSO) 1995.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1E01**
Title of the paper		**Official Statistics**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 1.5.2: ACTUARIAL STATISTICS

Semester	**I**
Paper code	**18UPSTA1E02**
Paper title	**Actuarial Statistics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

After finishing this chapter, you should be able to:

1. Analyse actuarial data using advanced statistical techniques
2. Calculate quantities such as premiums, reserves and superannuation contribution rates using actuarial techniques
3. Analyse real and hypothetical problems in insurance and superannuation
4. Demonstrate creativity and initiative in application of knowledge to problem solving and innovation.
5. Execute a project requiring research or a real-world application
6. Assess the suitability of actuarial, financial and economic models in solving actuarial problems.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Fit simple linear regression models and interpret model parameters.
- ✓ Demonstrate the necessary analytical skills for interpreting and analyzing actuarial and statistical information.
- ✓ Demonstrate well developed insight into the Australian and international financial markets.
- ✓ Demonstrate the skills necessary to critically engage with and evaluate actuarial and statistical problems.
- ✓ Assess and refine simple and multiple linear regression models based on diagnostic measures, identifying outlying and influential data points.

Unit I: Mortality:

Mortality: Level, trend and differentials in mortality - forces of mortality - Gombertz and Makeham laws of mortality- Complete and abridged life tables-construction, interpretation - applications -stationary funds.

Unit II: Annuities:

Annuities: Pure endowments - Annuities – Accumulations – Assurances - Varying annuities and assurances - Continuous annuities - family income benefits.

Unit III: Policy Values:
Policy Values: Nature of reserve - prospective and retrospective reserves - fractional premiums and fractional durations - modified reserves - Continuous reserves - Surrender values and paid up policies - Industrial assurance - Children's deferred assurances - Joint life and last survivorship.

Unit IV: Contingent Functions:
Contingent Functions: Contingent probabilities - Contingent assurances - reversionary annuities - multiple-decrement table - forces of decrement - construction of multiple decrement tables.

Unit V: Pension Funds:
Pension Funds: Capital sums on retirement and death - widow's pensions - Sickness benefits - Benefits dependent on marriage.

Books for Reference

1. Barcley G.W. (1970). Techniques of Population Analysis. John Wiley, New York.
2. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press.
3. Donald, D.W.A. (1970). Compound interest and annuities, Second Edition, The Institute of Actuaries and the Faculty of Actuaries at the University Press.
4. Elandt-Johnson, R.C., and Johnson, N. L. (1999). Survival Models and Data Analysis, John Wiley and Sons, New York.
5. King, G. Institute of Actuaries Textbook, Part II, Second Edition, Institute of Actuaries (Great Britain).
6. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1E02**
Title of the paper		**Actuarial Statistics**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 1.5.3: DATA MINING

Semester	**I**
Paper code	**18UPSTA1E03**
Paper title	**Data Mining**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

After finishing this chapter, you should be able to:

1. Interpret the contribution of data warehousing and data mining to the decision-support level of organizations.
2. Evaluate different models used for OLAP and data pre-processing categorize and carefully differentiate between situations for applying different data-mining techniques: frequent pattern mining, association, correlation, classification, prediction, and cluster and outlier analysis.
3. Design and implement systems for data mining.
4. Evaluate the performance of different data-mining algorithms.
5. Propose data-mining solutions for different applications.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Demonstrate an understanding of the importance of data mining and the principles of business intelligence.
- ✓ Organize and Prepare the data needed for data mining using pre-processing techniques.
- ✓ Perform exploratory analysis of the data to be used for mining.
- ✓ Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.
- ✓ Define and apply metrics to measure the performance of various data mining algorithms.

Unit I Introduction:

Data mining- Kinds of data – Data mining Functionalities - Classification of Data mining Systems - Major Issues on Data mining - Introduction to OLAP - OLAP technology for Data Mining - Data warehousing - Data warehousing to Data mining - Optimizing Data for mining - Data pre-processing.

Unit II Data Mining Primitives:

Data mining Query language - Association Rules in large - Data mining - KDD Process - Fuzzy sets and logic - Classification and Prediction: Information retrieval - Dimensional Modelling of Data - Pattern Matching - Estimation Error- EM and MLE.

Unit III Models based on Summarization:
Bayes Theorem - Chi square Statistics Regression - Decision Tree - Neural Networks - Genetic Algorithms - Cluster Analysis – Outlier - Cluster vs Classification - Clustering Issues - Impact of Outliers on clustering- Clustering problems - Clustering Approaches.

Unit IV Clustering Algorithms:
Hierarchical algorithm – Single Linkage - MST Single Linkage - Complete Linkage - Average Linkage.Dendrogram - Partition Algorithm – MST - Squared Error – *K* - Means - Nearest Neighbor – PAM – BEA – GA - Categorical algorithm - Large Database.

Unit VWeb Mining:
Introduction - Webdata - Web Knowledge Mining Taxonomy - Web Content mining - Web Usage Mining Research - Ontology based web mining Research - Web mining Applications.

Books for Reference

1. Berry, J.A., and Linoff, G.S. (2011). Data Mining Techniques, Third Edition, John Wiley and Sons, New York.
2. Chattamvelli, R. (2009). Data mining Methods, Alpha Science International.
3. Dunham, M.H. (2006). Data Mining: Introductory and Advanced Topics, Pearson Education India.
4. Gorunescu, F. (2010). Data mining Concepts, Models andTechniques, Springer.
5. Han, J., and Kamber, M. (2001). Data mining Concepts and Techniques, Seventh Edition, Morgan Kaufmann Publications.
6. Hand, D., Mannila, H., and Smyth, P. (2001). Principles of Data mining, MIT press.
7. Larose, D.T. (2005). Discovering Knowledge in Data: An Introduction to Data Mining. John Wiley and Sons, Canada.
8. Pujari, A.K. (2001). Data Mining Techniques, Universities Press.
9. Sivanandam, S.N., and Sumathi, S. (2006). Data Mining Concepts, Tasks and Techniques, Springer.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1E03**
Title of the paper		**Data Mining**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 1.6: STATISTICS PRACTICAL I

Semester	**I**
Paper code	**18UPSTA1P01**
Paper title	**Statistics Practical I**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

After finishing this chapter, you should be able to:

1. Identify the relation between the desired sample, the obtained sample, the sampling frame, and sample quality.
2. Non probability sampling methods may be preferred.
3. The concept of sampling error, the heterogeneity of the population, and the fraction of population included in the sample.
4. Identify possible values for each random variable.
5. Identify how changing values for a parameter affects the characteristics of the distribution.
6. Identify the mean and variance for each distribution

Course outcomes

Students who successfully complete the course should:

- ✓ understand the principles underlying sampling as a means ofmaking inferences about a population,
- ✓ be able to analyse data from multi-stage surveys
- ✓ appreciation of the practical issues arising in sampling studies.
- ✓ Calculate moments and generating functions
- ✓ Determine and interpret independence and conditional distributions
- ✓ Construct z, chi-squared, t and F tests and the corresponding confidence intervals from sample means and sample variances
- ✓ Apply chi-squared tests for contingency tables and goodness of fit

Exercise under Distribution Theory

1. Fitting of Binomial distribution.
2. Fitting of Poisson distribution.
3. Fitting of normal distribution by area and ordinate methods.

Exercise under Sampling Theory

1. Estimation of population total, mean and variance under simple random sampling.
2. Estimation of population total, mean and variance under stratified random sampling.
3. Estimation of population total, mean and variance under systematic sampling.

4.Estimation of population total, mean and variance under single - stage and two - stage cluster Sampling.
5. Ratio and regression estimates.
6. Estimation of population total, mean and variance under double sampling methods.

MODEL BLUEPRINT		
Subject Code		**18UPSTA1P01**
Title of the paper		**Statistics Practical I**
Unit Number	Number of hours	Total Marks
1	9	20
2	9	20
3	9	20
4	9	20
5	9	20
Total	45	60
Maximum marks for the paper		60

SEMESTER II

AIMS

1. To provide a broad based high quality education with combination of the subjects like Linear Algebra, Estimation Theory, Statistical Quality Control, Operation Research, Simulation and Statistical Modeling, Biostatistics, Supportive Paper I and Statistical Practical to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyse and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

SEMESTER 2.1: LINEAR ALGEBRA

Semester	**II**
Paper code	**18UPSTA2C05**
Paper title	**Linear Algebra**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:

1. Solve systems of linear equations using various methods including Gaussian and Gauss Jordan elimination and inverse matrices
2. Perform matrix algebra, invertibility and the transpose and understand vector algebra in R_n .
3. Determine relationship between coefficient matrix invertibility and solutions to a system of linear equations and the inverse matrices.

4. Define special matrices: diagonal, triangular, and symmetric
5. Understand determinants and their properties.
6. Understand real vector spaces and subspaces and apply their properties.
7. Understand linear independence and dependence.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

1. Students completing this course will be able to compute the inverse of an invertible matrix
2. Students completing this course will be able to find the null space of a matrix and represent it as the span of independent vectors.
3. Students completing this course will be able to find the matrix representation of a linear transformation given bases of the relevant vector spaces.
4. Find the dimension and basis of a a given vector space;
5. Write down the matrix representing a linear transformation (such as projection, rotation, dilation, etc.) under a given basis, and determine how the matrix changes if the basis is changed;
6. Test for independence of vectors;
7. Find the Gram-Schmidt orthogonalization of a matrix;
8. Determine the rank, determinant, Eigen values and eigenvectors, diagonalization, and different factorizations of a matrix.

Unit I:
Finite dimensional vector space, subspace, basis and dimension – Linear dependence and independence - Linear transformations of vectors and matrices – Rank of a matrix, null space and nullity of matrix.

Unit II:
Inner product for real and complex spaces – Properties of inner product, inner product space - Orthogonality of vectors and matrices – Orthonormalization process.

Unit III:
Characteristic roots and characteristic vectors - Cayley-Hamilton theorem. Minimum polynomial, similar matrices, algebraic and geometric multiplicities of a characteristic root - Spectral decomposition of a real symmetric matrix.

Unit IV:
Quadratic forms - Congruent transformations, congruence of symmetric matrices. Canonical reduction and orthogonal reduction of real quadratic forms - Nature of quadratic forms - Sylvester's law of inertia.Simultaneous reduction of a pair of quadratic forms.

Unit V:
Generalized inverse of matrix - Properties and computation of g – inverses - Moore-Penrose inverse - Vector and matrix derivatives.

Books for Study

1. Vasishta, A. R. (2005). Matrices. Krishna PrakashanMandir, New Delhi.

Books for Reference

1. Graybill, F.A. (1983). Matrices and Applications in Statistics, Wadsworth Publishing Company, Belmont, California, USA.
2. Hohn, F.E. (1971). Elementary Matrix Algebra, Amerind Publishing Co. Pvt Ltd., New Delhi.
3. Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Wiley Eastern, New Delhi.
4. Searle, S.R. (2006). Matrix Algebra Useful for Statistics, John Wiley, New York.
5. Ayres, F. Jr. (1965). Modern Abstract Algebra, First Edition, McGraw-Hill Professional Publishing.
6. Hoffman, K., and Kunze, R. (1975). Linear Algebra, Second Edition, Prentice Hall of India, New Delhi.
7. Kumaresan, S. (2000). Linear Algebra: A Geometric Approach,PHI Learning.
8. Rao, A. R., and Bhimasankaram, P. (2000). Linear Algebra, Second Edition, Hindustan Book Agency, Hyderabad.

MODEL BLUEPRINT		
Subject Code		**17UPSTA1E02**
Title of the paper		**Linear Algebra**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.2: ESTIMATION THEORY

Semester	**II**
Paper code	**18UPSTA2C06**
Paper title	**Estimation Theory**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objective

After finishing this chapter, you should be able to:

1. Use Minimum mean square error criterion, Unbiased Estimators MVUE – Sufficient Statistics.
2. Fisher's information measure, Cramer-Rao inequality, Bhattacharya's inequality, Chapman, Robbins inequality and Fisher's information matrix.

3. Derive and Neymann Factorization theorem and applications.
4. Understand MLE and their relationship with probability distributions
5. Compute CAN Estimators, Consistent estimators, Asymptotic properties of maximum likelihood estimators, Pitman families of distributions, Method of least squares.

Course outcomes

Upon successful completion, students will have the knowledge and skills to

- ✓ Apply basics of probability theory in system identification and system state estimation
- ✓ Explain application ways for non-parametric system identification methods and suitability of their use in corresponding system surrounding
- ✓ Combine tools for carrying out non-parametric system identification methods and validation of the obtained system models
- ✓ Explain application ways for parametric system identification methods and suitability of their use in corresponding system surrounding
- ✓ Combine tools for carrying out parametric system identification methods and validation of the obtained system models
- ✓ Design state estimator for linear deterministic and stochastic systems.

Unit I

Point Estimation – Minimum mean square error criterion – Unbiased Estimators MVUE – Sufficient Statistics- Neymann Factorization theorem - Minimal sufficiency - Exponential family of distributions – Uniformly minimum variance unbiased estimator - Rao-Blackwell's theorem - Lehmann - Scheffe's theorem.

Unit II

Fisher's information measure – Cramer-Rao inequality - Bhattacharya's inequality – Chapman - Robbins inequality – Fisher's information matrix – simultaneous in parameters of univariate normal distribution.

Unit III

Methods of estimation – method of moments – method of maximum likelihood estimators – Properties - Method of minimum chi square - Method of modified minimum chi- square estimators.

Unit IV

Consistency and CAN Estimators - Consistent estimators – Asymptotic properties of maximum likelihood estimators – Pitman families of distributions – Method of least squares.

Unit V

Interval estimation – General method of constructing confidence interval – Construction of shortest average width confidence intervals – Construction of confidence intervals in large samples and small samples (Mean, Proportions, Variance) – Construction of most accurate confidence intervals.

Books for Study

1. Casella G and Berger R L, (2002). Statistical Inference, Second Edition, Thompson Learning, New York. (Reprint, 2007).

2. Goon, A M, Gupta M.K and Dasgupta B, (1989), An Outline of Statistical Theory, Vol. II, World Press, Kolkata.
3. Rajagopalan M and Dhanavanthan P, (2012), Statistical Inference, PHI Learning Pvt. Ltd., New Delhi.

Books for Reference

1. Bansal, A.K, (2007), Bayesian Parametric Inference, Narosa Publishing House, New Delhi.
2. Mood A.M, Graybill F.A and Boes D.C, (1974), Introduction to Theory of Statistics, Third Edition, McGraw-Hill International Edition.
3. Rohatgi, V.K and Saleh, A.K.Md.E, (2011), An Introduction to Probability and Statistics Second Edition, John Wiley & Sons, New York.
4. Berger, J.O, (1985), Statistical Decision Theory and Bayesian Analysis, Second Edition, Springer Verlag, New York.
5. Kale, B.K, (2005), A First Course in Parametric Inference, Second Edition, Narosa Publishing House, New Delhi. (Reprint, 2007).
6. Kale, B.K., and Muralidharan, K, (2015), Parametric Inference, Narosa Publishing House, New Delhi.
7. Keith, K, (2000), Mathematical Statistics, Chapman and Hall/CRC, New York.
8. Lehmann, E.L., and Casella, G, (1998), Theory of Point Estimation, Second Edition, Springer Verlag, New York. (Reprint, 2008).
9. Manoj Kumar Srivastava, Abdul Hamid Khan, NamitaSrivastava, (2014), Statistical Inference: Theory Of Estimation, PHI Learning, New Delhi.
10. Mukhopadhyay, P, (2002), Mathematical Statistics, Book and Allied Publishers, New Delhi.
11. Rao, C.R, (1973), Linear Statistical Inference and Its Applications, Second Edition, Wiley Eastern Ltd., New Delhi.
12. Santhakumaran A. (2004), Probability Models and their Parametric Estimation, K.P. Jam Publication, Chennai.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2C06**
Title of the paper		**Estimation Theory**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 2.3: STATISTICAL QUALITY CONTROL AND RELIABILITY

Semester	**II**
Paper code	**18UPSTA2C07**
Paper title	**Statistical Quality Control and Reliability**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

After finishing this chapter, you should be able to:
1. It provides a means of detecting error at inspection.
2. It leads to more uniform quality of production.
3. It reduces the number of rejects and saves the cost of material.
4. It provides a means of determining the capability of the manufacturing process.
5. It provides a means of determining the capability of the manufacturing process.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…
- ✓ Understand the philosophy and basic concepts of quality improvement.
- ✓ Describe the DMAIC process (define, measure, analyze, improve, and control).
- ✓ Demonstrate the ability to use the methods of statistical quality control.
- ✓ Perform analysis of process capability and measurement system capability.
- ✓ Demonstrate the ability to design, use, and interpret control charts for variables and attributes.

Unit I: Introduction and Chart types of SQC:
Statistical Quality Control - Introduction - Shewhart Control Charts for , *R, , np, p, c* and their uses, OC and ARL of Control Charts, Control Charts based on C.V., Modified Control Charts, CUSUM procedures, use of V-mask, Derivation of ARL.

Unit II: CUSUM charts:
Decision Interval Schemes for CUSUM charts - Economic Designs of Control Charts, Pre-control, Relative Precision and Process Capability analysis and Gauge capability analysis, Multivariate Control charts and HotellingT^2.

Unit III: Sampling Techniques:
Basic Concepts Of Acceptance Sampling, Single, Double, Multiple and Sequential Sampling Plans for Attributes, Curtailed and Semi Curtailed Sampling - Dodge-Romig Tables-LTPD and AOQL Protection (Single Sampling Plan Only) - MIL-STD-105D.

Unit IV: Variable Sampling:
Variable Sampling: Assumptions, Single and Double Variable Sampling Plans. Application of Normal and Non-central *t* - Distributions in Variable Sampling - Continuous Sampling Plans: CSP-1, CSP-2 and CSP-3. Special Purpose Plans: Chain Sampling Plans, Skip-lot Plans.

Unit V: Six-Sigma:
Quality Policy and Objective – Planning and Organization for Quality – Quality Policy Deployment – Quality Function deployment – Quality Audit – Need for ISO 9000 Systems – Clauses – Documentation – Implementation – Introduction to QS 9000 – Implementation of Quality Management System - Six Sigma – Evaluation of Six Sigma.

Books for Study

1. Montgomery, D.C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.
2. John T. Burr, (2004) Elementary Statistical Quality Control (Second Edition), Marcel Dekker New York.
3. Duncan, A.J. (2006). Quality Control and Industrial Statistics, Irwin - Illinois.

Books for Reference

1. Grant, E.L., and Leavenworth, R.S. (2000). Statistical Quality Control, Seventh Edition, Tata McGraw Hill, New Delhi.
2. Juran, J.M., and De Feo, J.A. (2010). Juran's Quality control Handbook – The Complete Guide to Performance Excellence, Sixth Edition, Tata McGraw-Hill, New Delhi.
3. Mahajan, M. (2002). Statistical Quality Control, (Third Edition), DhanpatRai and Co., Delhi.
4. Schilling, E. G., and Nuebauer, D.V. (2009). Acceptance Sampling in Quality Control Second Edition, CRC Press, New York.
5. Wetherill, G.B. (1977). Sampling Inspection and Quality Control, Second Edition, Chapman and Hall, London.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2C07**
Title of the paper		**Statistical Quality Control**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 2.4.1: OPERATIONS RESEARCH

Semester	**II**
Paper code	**18UPSTA2E04**
Paper title	**Operations Research**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Understand the meaning, purpose, and tools of Operations Research
2. Describe the history of Operations Research
3. Describe the Stages of O.R
4. Explain the Applications of Operations Research
5. Describe the Limitations of Operation Research
6. Understand the OR specialist and Manager relationship

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Identify and develop operational research models from the verbal description of the real system.
- ✓ Understand the mathematical tools that are needed to solve optimization problems.
- ✓ Use mathematical software to solve the proposed models.
- ✓ Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

Unit I: Operation Research:

Operations Research: Meaning, Objectives and Scope. Phases of Operations Research Linear Programming Problem (LPP): General Formulation - Illustrations – Methods of Solving LPP - Graphical and Simplex Methods – Concept of Cycling and Degeneracy. Problem of Duality - Dual Simplex Method – Simple Problems.

Unit II: Transportation Problems:

Transportation Problems (TP): Mathematical Formulation – Illustrations - Relationship Between TP and LPP – Methods for finding Basic Feasible Solutions – Optimality – Transportation Algorithm – Concept of Degeneracy – Unbalanced Transportation Problem. Assignment Problem – Formulation - Illustrations – Method of solving an Assignment Problem.

Unit III: Queueing Theory:

Queueing Theory: Queueing models – Queueing system – Queueing problem - Definition of transient and steady-states - Kendall's notations and classification of queuing models - Distributions in queuing systems - Solution of queuing models: Model I: (M/M/1:∞/FCFS) - Birth and Death Model. Model-II - General Erlangian queueing model (Birth-Death Process). ModelIII: (M/M/1: N/FCFS) and Model IV: (M/M/S/FCFS) - Steady-state solutions of Markovian queuing models of M/M/1, M/M/C and M/G/1 with limited waiting spaces.

Unit IV: Theory of Inventory:
Theory of Inventory: Meaning of Inventory – Economic Order Quantity - Deterministic and Probabilistic Inventory Models - Models with and without shortages – Concept of ABC Analysis. Game Theory: Zero-sum games, Maximin and Minimax Criteria – Minimax and Saddle Point Theorems – Dominance Property.

Unit V: Replacement Problems:
Replacement Problems: Replacement of deteriorating items – Complete replacement of items – Individual and Group Replacement Policies. Network Analysis: Concept – Network Diagram – Fulkerson's Rule.Project Management and Scheduling. PERT and CPM: Meaning and Description – Determination of Critical Path.

Books for Study

1. Swarup, K., Mohan, M., and Gupta P.K. (2001). Operations Research, Sultan Chand and Sons, New Delhi.

Books for Reference

1. Gupta, P.K., and Man Mohan. (1979). Operations Research: Linear Programming and Theory of Games, Third Edition, Sultan Chand and Sons, New Delhi.
2. Gass, S. I. (1985). Linear Programming, Methods and Applications.Courier Dover Publications. (Reprint 2003)
3. Hadley, G (1963): Linear Programming. Addison Wesley Publishing Company.
4. Hillier, F.S., and Lieberman, G.J. (2005). Introduction to Operations Research, Ninth Edition, McGraw – Hill Publishing Company.
5. Sharma, J.K. (2013). Operations Research: Problems and Solutions, Fifth Edition, Macmillan India Limited.
6. Sharma, S. D. (2010). Operations Research, KedarNath, Ram Nath and Co, Meerut.
7. Taha, H.A (2011). Operations Research: An Introduction, Ninth Edition, Prentice Hall Publishing Company.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2E04**
Title of the paper		**Operations Research**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.4.2: SIMULATION AND STATISTICAL MODELING

Semester	**II**
Paper code	**18UPSTA2E05**
Paper title	**Simulation and Statistical Modeling**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Define the basics of simulation modeling and replicating the practical situations in organizations

1. Generate random numbers and random variants using different techniques.
2. Develop simulation model using heuristic methods.
3. Analysis of Simulation models using input analyzer, and output analyzer
4. Explain Verification and Validation of simulation model.

Course outcome

- ✓ Understand different methods for random number generation
- ✓ Understanding of the need for the development process to initiate the real problem.
- ✓ Understanding of principle and techniques of simulation methods informed by research direction.
- ✓ Be able to discuss the simulation methods and select the suitable technique on the problems.
- ✓ Know how to simulate any discrete system using queuing systems
- ✓ Use a range of commercial software packages to construct, verify and validate models of the given systems

Unit I: Simulation and its Types

Simulation: Introduction, appropriate and not appropriate, advantages and disadvantages, application areas. System and system environment, components of system, type of systems, model of a system, types of models and steps in simulation study.

Unit II: Models in Simulation

Statistical Models in Simulation: Useful statistical model, discrete distribution, continuous distribution, empirical distribution - Poisson distribution, Uniform distribution, Exponential distribution, Triangular distribution, Gamma distribution.

Unit III: Random number and variate

Random Number Generation: Properties of random numbers, generation of true and pseudo random numbers, techniques for generating random numbers, hypothesis testing, various tests for uniformity (Kolmogorov-Smirnov and chi-Square) and independence (runs, autocorrelation). Random Variate Generation: Introduction, different techniques to generate random variate - inverse and direct transform techniques, convolution method and acceptance rejection techniques.

Unit IV: Input Modeling

Input Modeling: Introduction, steps to build a useful model of input data, data collection, identifying the distribution with data, parameter estimation, suggested estimators, goodness of fit tests, selection input model without data, covariance and correlation, time series input models.

Unit V: Validation of Models

Verification and Validation of Simulation Models: Model Building - Verification and Validation - Verification of Simulation models - Calibration and Validation of models: Face Validity - Validation of model Assumptions - Validations Input-Output Transformations - Input-Output Validation using Historical Input Data - Input-Output Validation using a Turing Test.

Books for Reference

1. Banks J., Carson J. S., Nelson B. L., and Nicol D. M. (2001). Discrete Event System Simulation, Third Edition, Pearson Education.
2. Deo, N. (1983). System Simulation with Digital Computer, Prentice Hall of India (Digitized 2007).
3. Gardon, G. (1992). System Simulation, Second Edition, Prentice Hall of India.
4. Law, A.M. (2007). Simulation Modeling and Analysis, Fourth Edition, McGraw-Hill Education.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2E05**
Title of the paper		**Simulation and Statistical Modeling**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.4.3: BIOSTATISTICS

Semester	**II**
Paper code	**18UPSTA2E06**
Paper title	**Bio-Statistics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Understand and apply statistical methods for the design of biomedical research an d analysis of biomedical research data
2. Understand and use mathematical and statistical theory underlying the application of bio statistical methods;
3. Learn to participate in a research team setting in study design, datacoordination a ndmanagement, and statistical analysis and reporting of study results
4. Participate in a research team in the development and evaluation of new and existi ng statistical methodology.

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation.
- ✓ Select from, use, and interpret results of, the principal methods of statistical inference and design.
- ✓ Communicate the results of statistical analyses accurately and effectively.
- ✓ Make appropriate use of statistical software.
- ✓ Read and learn new statistical procedures independently.

Unit I: Biological Concepts:

Introduction Definition/Phases of Clinical Trials; Study Design: Cohort, case-control and observational studies; Terminology of prospective, retrospective; treatment allocation, randomization and stratification, quality control, biases, sample size requirements, patient consent Hypotheses / Aims: superiority, non-inferiority, equivalence primary, secondary; various types of clinical data (continuous, categorical, count, and time-to-event outcome data); Basic biological concepts in genetics, Basic concept of Bioassays and different Types of biological assays.

Unit II: Exposure Association and Contingency Tables:

Disease-Exposure Association: Risk, odds, odds ratio, relative risk, standard errors; Contingency Tables: Association (Chi-square test), Confounding (Mantel-Haenszel), Interactions (Test of homogeneity); Probability Diagnostic Testing and Screening.

Unit III: Descriptive Statistics:

Descriptive Statistics; Estimation for Means; Estimation for Proportions; One Sample Hypothesis Test – Means ; One Sample Hypothesis Test – Proportions; Two Sample Hypothesis Test; NonParametric Hypothesis Testing; One Way ANOVA.

Unit IV: Linear and Logistic Regression:

Introduction to Linear Regression and Correlation; Logistic Regression: estimation: Logistic regression for case-control studies, estimation and interpretation of logistic parameters.

Unit V: Introduction to Survival:

Introduction to Survival: Concepts of time, Censoring-different types of censoring-right and left, Survival function- Kaplan-Meier (K-M) estimator; Nonparametric Methods for Comparing Survival Distributions - log rank test, Peto's test, Gehan test, Mantel-Haenzel test. Cox Proportional Hazard regression, parametric survival models –

Basic life time distributions - Exponential, Weibull, Gamma Log-Normaland Log-logistic.

Books for Study

1. Rossi R.J. (2010).Applied Biostatistics for Health Sciences, Wiley.
2. Fundamentals of Biostatistics: Bernard Rosner Recommended 6th /7th Edition.

Books for Reference

1. Friedman, Furberg&DeMets: Fundamentals of Clinical Trials, 3rd Edition, 1996. Mosby-Year Book, Inc.
2. Cox, P.R. (1978): Demography (Fifth Edition). Cambridge University Press.
3. David G. K., and Klein, M. (2008). Survival analysis - A Self-Learning Text, Second edition, Springer
4. Lee, E. T., and Wenyu, J. (2003). Statistical methods for Survival Data Analysis, Third Edition, John Wiley & Sons.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2E06**
Title of the paper		**Biostatistics**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.5.1: BASIC STATISTICAL METHODS

Semester	**II**
Paper code	**18UPSTA2S01**
Paper title	**Basic Statistical Methods**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Demonstrate knowledge of probability and the standard statistical distributions.
2. Demonstrate knowledge of fixed-sample and large-sample statistical properties of point and interval estimators.
3. Demonstrate knowledge of the properties of parametric, semi-parametric and nonparametric testing procedures.
4. Demonstrate the ability to perform complex data management and analysis.
5. Demonstrate the ability to apply linear, nonlinear and generalized linear models.

6. Demonstrate understanding of how to design experiments and surveys for efficiency.
7. Demonstrate knowledge of classical and repeated measures multivariate methods and computational techniques.

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Recognize and apply some common probability distributions, and assess if underlying assumptions for the distribution seem reasonable.
- ✓ Be able to perform basic statistical calculations and graphical analyses.
- ✓ Analyze research questions based on statistical data, draw relevant conclusions, and be familiar with the limitations of particular statistical methods.
- ✓ Be able to discuss and reflect upon ethical topics relevant to statistical methods.

Unit I

Definition of Statistics and its applications in various disciplines - Collection of Data - classification, Tabulation and Graphical representation of data - construction of univariate and Bivariate frequency distribution - Measures of central tendency - Measures of dispersion - coefficient of variation.

Unit II

Random experiment - sample space - events - mathematical and statistical definition of probability - conditional probability – Bayes' theorem - Random variables - Distribution functions - moments - Binomial distribution - Poisson distribution - Normal distribution and their properties.

Unit III

Scatter diagram - Karl Pearson's coefficient of correlation - concurrent deviation method - coefficient of determination - Spearman's Rank correlation -Linear regression–fitting of regression lines.

Unit IV

Tests of significance - hypotheses - two types' of errors - power function - critical region - level of significance – small sample tests based on t and F distributions. Chi-square test of goodness of fit - contingency table -Test of independence of factors - Large sample tests.

Unit V

Test of equality of several population means one way and two way analysis of variance - Non-parametric tests Sign, Run and Median tests - two sample rank test - Sampling and its uses, sampling methods - Simple random sampling, systematic and stratified

Books for Study and Reference

1. Agarwal, B.L. (2013). Basic statistics.Anshan Publications.
2. Sharma, J.K. (2007). Business Statistics (Second Edition). Pearson Education, New Delhi.
3. Sokal, P.R. and Rohlf, F.J. (1969). Bio Statistics. W.H. Freeman and Co., San Francisco.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2S01**
Title of the paper		**Basic Statistical Methods**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.5.2: STATISTICS FOR BEHAVIORAL SCIENCES

Semester	**II**
Paper code	**18UPSTA2S02**
Paper title	**Statistics for Behavioral Science**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of the course the student will be able to:
1. Distinguish among different scales of measurement and their implications;
2. Interpret data displayed in tables and graphically;
3. Apply concepts of sample space and probability;
4. Calculate measures of central tendency and variation for a given data set;
5. Identify the standard methods of obtaining data and identify advantages and disadvantages of each.

Course outcomes

Students who successfully complete the course should:
- ✓ Explain the major concepts, theoretical perspectives and empirical findings in psychology
- ✓ Evaluate the major methods of inquiry and statistical analysis in psychology
- ✓ Discuss the ways in which diversity influences psychological processes
- ✓ Critically analyze existing literature on a topic in psychology
- ✓ Design research studies, including the application of statistical procedures
- ✓ Discuss how psychological principles can be used to explain social issues, address pressing societal needs and/or inform public policy (aligns with new core and social behavioral inquiry)

Unit I:

Nature and scope of Statistics - characteristics and limitation of Statistics - statistical investigation - preparation of questionnaire - design of sampling - simple random, stratified and systematic sampling - collection of data - primary and secondary data.

Unit II:
Processing and presentation of data - Classification of data - tabulation of data - Formation of frequency tables - Diagrammatic presentation of statistical data - bar diagrams - pie diagrams and pictograms - simple problems – Graphical presentation of statistical data - Histogram, frequency curves and Ogive curve- simple problems.

Unit III:
Measures of central tendency - mean, median, mode - simple problems - measures of dispersion - range, mean deviation, quartile deviation and standard deviation - relative measures of dispersion - simple problems.

Unit IV:
Concept of Skewness and Kurtosis - Karl Pearson's and Bowley's coefficients of Skewness- moments- coefficients of Skewness and Kurtosis - simple problems.

Unit V:
Correlation: Scatter diagram - simple correlation, Rank correlation. Regression - simple regression lines (without proof) - Tetrochoric correlation, Phi coefficient and Kendall's co-efficient - simple problems.

Books for Study and Reference

1. Camphell, R.C. (1989). Statistics for Biologists, Cambridge University Press, London.
2. Garret, H. E., and Woodworth, R. S. (2006). Statistics in Psychology and Education.Cosmo Publications, New Delhi.
3. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Volume-I, World Press Ltd, Calcutta.
4. Gupta, S. C., and Kapoor, V. K. (2000). Fundamentals of Mathematical Statistics, Tenth Edition, Sultan Chand and Sons, New Delhi.
5. Saxena, H. C. (1967). Elementary Statistics, Sultan Chand & Co., New Delhi.
6. Tate, M. W. (1964). Statistics in Education. Macmillan Co., New York. Y

MODEL BLUEPRINT		
Subject Code		**18UPSTA2S02**
Title of the paper		**Statistics For Behavioral Sciences**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.5.3: PROBABILITY AND STATISTICS FOR SCIENTISTS

Semester	**II**
Paper code	**18UPSTA2S03**
Paper title	**Probability and Statistics for Scientists**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of the course the student will be able to:

Knowledge

1. Apply probability theory to set up tree diagrams.
2. Apply probability theory via Bayes' Rule.

Skills

1. Able to apply the central limit theorem to sampling distribution
2. Able to use estimation technique to determine point estimates confidence interval and sample size.

Attitudes

1. Able to solve problems independently.
2. Able to appreciate the diversity of the applications of central limit theorem.
3. Able to appreciate the diversity of the applications of hypothesis testing

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

1. Apply key concepts of probability, including discrete and continuous random variables, probability distributions, conditioning, independence, expectations, and variances.
2. Define and explain the different statistical distributions (e.g., Normal, Binomial, Poisson) and the typical phenomena that each distribution often describes.
3. Apply the basic rules and theorems in probability including Bayes's theorem and the Central Limit Theorem (CLT).
4. Define and demonstrate the concepts of estimation and properties of estimators.
5. Apply the concepts of interval estimation and confidence intervals.
6. Apply the concepts of hypothesis testing and p-value.

Unit I

Sample spaces – events – Probability axioms – Conditional Probability – Independent events – Baye's formula - Random Variables - Distribution functions – Marginal distributions, Conditional distribution – Stochastic Independence - Expectation – Conditional expectation and Conditional Variance.Moment generating functions – Cumulant generating functions.

Unit II

Probabilty distributions – Binomial, Poisson, geometric, uniform, exponential, normal, gamma, beta (generating function, Mean, variance and Simple problems).Sampling distributions - *t*, *f*, Chi-square distributions- properties.

Unit III

Estimation: Point estimation – Characteristics of estimation – Interval estimation – Interval estimates of Mean, Standard deviation, proportion, difference in means and ratios of standard deviations.

Unit IV

Test for means, Variances & attributes using the above distributions large sample tests – tests for means, variances and proportions. Analysis of Variance: One way and two way classifications – Complete Randomized blocks – Randomized Block Design and Latin Square Design (Only Problems).

Unit V

Statistical quality control – Statistical basis for control charts – Control limits – Control Charts for variables and attributes – mean chart, range chart, standard deviation chart - charts for defectives, defects – *p*, *np*, *c* charts.

Books for Study and Reference

1. Gupta, S.C., and Kapoor, V. K. (1977). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Montgomery, D.C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.
3. Montgomery, D.C., and Runger, G. C. (2010), Applied Statistics and Probability for Engineers, Fifth Edition, John Wiley & Sons, New York.

MODEL BLUEPRINT		
Subject Code		18UPSTA2S03
Title of the paper		Probability and Statistics for Scientists
Unit Number	Number of hours	Total Marks
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.5.4: STATISTICS FOR RESEARCHERS

Semester	**II**
Paper code	**18UPSTA2S04**
Paper title	**Statistics for Researchers**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objective

Upon successful completion of the course the student will be able to:

1. Identify and utilize relevant previous work that supports their research
2. Articulate a timely and important research question or creative objective
3. Identify and utilize appropriate methodologies to address the research question or creative objective
4. Meet the relevant field's standards for the responsible conduct of research, and effectively navigate challenges that arise in the research process
5. Work collaboratively with other researchers, demonstrating effective communication and problem-solving skills
6. Present the research effectively in a conference setting and a written publication

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ research design considerations (question formulation, sample selection and randomisation, study design, and research protocols)
- ✓ data types, and appropriate summaries and graphs of samples and differences
- ✓ standard errors, confidence intervals and p-values
- ✓ parametric and nonparametric assumptions and tests

Unit I

Definition of Statistics and its applications in various disciplines - Collection of Data - Classification, Tabulation and graphical representation of data- Construction of univariate and bivariate frequency distribution-measures of central tendency-measures of dispersion coefficient of variation.

Unit II

Random experiment-sample space-events-mathematical and statistical definition of probability-conditional probability - Baye's theorem - random variable - distribution function - moments - Binomial distribution - Poisson distribution - normal distribution and their properties

Unit III

Scatter diagram - Karl Pearson's coefficient of correlation - concurrent deviation method coefficient of determination - Spearman's Rank correlation - Linear regression - regression lines.

Unit IV

Tests of significance - types of hypotheses - two types of errors - critical region - level of significance, small sample tests based on t, F distribution, Chi - square test of

goodness of fit, contingency table - test of independence of factors - Large sample tests.

Unit V

Test of equality of several population means, one way and two way analysis of variance. Non-parametric tests - sign, run and median tests - two sample rank test - sampling and its uses, sampling methods - unrestricted Random sampling (SRS) - Restricted Sampling (Stratified and Systematic).

Books for Study and Reference

1. Agarwal (1980). Basic Statistics, Wiley Eastern.
2. Goon,A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Volume-I, World Press Ltd, Calcutta.
3. Gupta, S. C., and Kapoor, V. K. (2000). Fundamentals of Mathematical Statistics, Tenth Edition, Sultan Chand and Sons, New Delhi.
4. Sokal, P. R., and Rohlf, F. J. (1969). Bio Statistics, W.H. Freedom & Co, San Francisco.
5. Snedecor, G. W., and Cochran, W. G. (1967). Statistical Methods, Oxford-IBH, Pvt Co.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2S04**
Title of the paper		**Statistics for Researchers**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 2.6: STATISTICS PRACTICAL II

Semester	**II**
Paper code	**18UPSTA2P02**
Paper title	**Statistical Practical II**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Students will be able to make inferences using evidence and background knowledge.
2. It provides a means of detecting error at inspection.
3. It leads to more uniform quality of production.

4. It improves the relationship with the customer.
5. It reduces inspection costs.
6. It reduces the number of rejects and saves the cost of material.
7. It provides a basis for attainable specifications.
8. It points out the bottlenecks and trouble spots.
9. It provides a means of determining the capability of the manufacturing process.

Course outcomes

Upon successful completion of the requirements of this course, students should have the knowledge and skills to:

- ✓ Explain in detail the notion of a parametric model and point estimation of the parameters of those models.
- ✓ Demonstrate the plausibility of pre-specified ideas about the parameters of the model by examining the area of hypothesis testing.
- ✓ Understand the philosophy and basic concepts of quality improvement.
- ✓ Describe the DMAIC process (define, measure, analyze, improve, and control).
- ✓ Demonstrate the ability to use the methods of statistical process control. Demonstrate the ability to design, use, and interpret control charts for variables.
- ✓ Demonstrate the ability to design, use, and interpret control charts for attributes.
- ✓ Perform analysis of process capability and measurement system capability.
- ✓ Design, use, and interpret exponentially weighted moving average and moving average control charts.

Exercise under Statistical Inference

1. Estimation of parameters under normal and exponential distributions by the methods of moments, maximum likelihood and minimum chi - square.
2. Estimation of confidence intervals for the mean, standard deviation, variance, difference of two means, standard deviations, ratio of variances based on normal, student's t, Chi-square and F distributions.

Exercise under Statistical Quality Control

1. Construction of control charts for mean, range and standard deviation.
2. Construction of control charts for fraction defective, number of defectives, number of defects and average number of defects per unit (p, np, c and u charts).
3. Construction of tabular CUSUM, moving - average and geometric moving - average control charts.
4. Construction of OC, ASN, ATI and AOQ curves of single and double sampling plans.

MODEL BLUEPRINT		
Subject Code		**18UPSTA2P02**
Title of the paper		**Statistics Practical II**
Unit Number	**Number of hours**	**Total Marks**
1	9	20
2	9	20
3	9	20
4	9	20
5	9	20
Total	45	60
Maximum marks for the paper		60

SEMESTER III

AIMS

1. To provide a broad based high quality education with combination of the subjects like Hypothesis Testing, Multivariate Analysis, Demographic Methods, Econometrics, Categorical Data Analysis, Statistics methods for Epidemiology, Supportive Paper II and Statistical data analysis using R to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in statistical computation.

SEMESTER 3.1: HYPOTHESIS TESTING

Semester	**III**
Paper code	**18UPSTA3C08**
Paper title	**Hypothesis Testing**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

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

1. Develop null and alternative hypotheses to test for a given situation.
2. Understand the difference between one- and two-tailed hypothesis tests.
3. Understand Type I and Type II errors
4. Able to do hypothesis test about population mean when σ is known
5. Able to do hypothesis test about population mean when σ is unknown

Course outcomes

Upon successful completion, students will have the knowledge and skills to

- ✓ Be able to state appropriate null and alternative hypotheses.
- ✓ Appropriate means that you know whether it should be one or two sided and which should be null, which alternative.
- ✓ Be able to calculate a p-value.
- ✓ Be able to interpret a p-value.
- ✓ Be able to state the relationship between a CI for μ and a test about μ (one or two sided)

Unit I

Testing of hypotheses: simple and composite hypotheses, two types of errors, level of significance, power and size of a test.Most powerful test – Neyman-Pearson lemma.Monotone likelihood ratio property - uniformly most powerful tests.

Unit II

Generalization of Neyman-Pearson fundamental lemma (statement only). Unbiased tests for one-parameter exponential family of distributions and multi - parameter - exponential family of distributions - Locally most powerful (LMP) test - LMP unbiased test.

Unit III

Invariance - maximal invariant statistic - invariant test - Likelihood ratio (LR) test - asymptotic distribution of LR test criterion -consistency of LR test - Construction of LR tests for standard statistical distributions – Likelihood ratio test for categorized data.

Unit IV

Nonparametric Estimation – Empirical distribution function - U statistic – Single sample problems - Tests for goodness of fit – Chi square and Kolmogorov – Smirnov tests – Sign Test - Wilcoxon's signed rank test - Kolmogorov - Smirnov two sample test - Mann - Whitney U test - Kruskal - Wallis test – Median Test – Friedman's Test.

Unit V

Introduction to sequential procedures - Stopping times - Wald's equation. SPRT: Termination property, approximation to stopping bounds and applications to standards distributions - OC and ASN functions.

Books for Study

1. Casella, G. and Berger, R.L. (2002). Statistical Inference (Second Edition). Thompson Learning, New York. (Reprint, 2007).
2. Gibbons, J. D., and Chakraborti, S. (2010). Nonparametric Statistical Inference (Fifth Edition).Taylor & Francis, New York.
3. Goon, A.M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory, Vol. II, World Press, Kolkata.
4. Kale, B. K. (2005). A First Course in Parametric Inference (Second Edition).Narosa Publishing House, New Delhi. (Reprint, 2007).
5. Lehmann, E. L. and Romano, J.P.(2005). Testing Statistical Hypotheses (Third Edition), Springer Verlag, New York. (Reprint, 2009).

6. Rao, C.R. (1973). Linear Statistical Inference and Its Applications (Second Edition), Wiley Eastern Ltd., New Delhi.
7. Rohatgi, V.K. and Saleh, A.K.Md.E.(2001). An Introduction to Probability and Statistics (Second Edition), John Wiley & Sons, New York. (Reprint, 2009).
8. Manoj Kumar Srivastava, Abdul Hamid Khan, NamitaSrivastava, (2014), Statistical Inference: Theory Of Estimation, PHI Learning, New Delhi.
9. Mukhopadhyay, P, (2002), Mathematical Statistics, Book and Allied Publishers, New Delhi.
10. Santhakumaran A. (2004), Probability Models and their Parametric Estimation, K.P. Jam Publication, Chennai.
11. Wald, A. (1982). Sequential Analysis, John Wiley & Sons, New York.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3C08**
Title of the paper		**Hypothesis Testing**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 3.2: MULTIVARIATE ANALYSIS

Semester	**III**
Paper code	**18UPSTA3C09**
Paper title	**Multivariate Analysis**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. Analyze multivariate data and the dependence structure of variates to extract the useful information from a massive dataset;
2. Apply suitable tools for exploratory data analysis, dimension reduction, and classification to formulate and solve real-life problems;
3. Implement the multivariate analysis techniques with statistical software such as R in a manner that the methodology adopted is motivated by appropriate statistical theory.

Course outcomes

On successful completion of the course, a student should be able to demonstrate…

- ✓ The student will appreciate the range of multivariate techniques available
- ✓ will be able to summarize and interpret multivariate data
- ✓ will have an understanding of the link between multivariate techniques and corresponding univariate techniques
- ✓ Will be able to use multivariate techniques appropriately, undertake multivariate hypothesis tests, and draw appropriate conclusions.

UNIT I: Introduction of Multivariate Normal Distribution:
Singular and non-singular multivariate normal distributions and their properties - Marginal and conditional distributions - Characteristic function and moments - Distribution of linear combinations of multivariate normal vector - Determination of mean and variance - covariance matrix of multivariate normal distribution.

UNIT II: Random Sampling:
Random Sampling from multivariate normal distribution - Maximum likelihood estimators of the parameters of multivariate normal distribution - distribution of sample mean vector - Necessary and sufficient conditions for a quadratic form to be distributed with a chi - square distribution - Inference concerning the sample mean vector when covariance matrix is known.

UNIT III: Statistic and Its Distribution:
Generalized T2 statistic and its distribution - Hotelling's T2 statistic, properties, applications and its distribution- Two sample problems with unequal covariance matrices likelihood ratio criterion and its applications - Mahalanobis D2 statistic and its distribution - Relationship between T2 and D2 statistics – Behrens – Fisher problem.

UNIT IV: Discriminant Function:
Wishart distribution - Sampling distribution of sample covariance matrix - Properties of Wishart distribution - Wilk's criterion - Generalized variance (Concept only) - Sampling distribution of simple sample correlation coefficient - Sampling distribution of partial and multiple correlation coefficients in null case (without derivation) - Tests concerning simple, partial and multiple correlation coefficients - Discriminant function (concept only) - Fisher's discriminant function.

UNIT V: Principal Component Analysis:
Problem of classification - Two populations and k populations - Principal components and their determination - Factor analysis – Cluster analysis estimation of factor loadings - Canonical variables and canonical correlations - Derivation of canonical correlation coefficients.

Books for Study:

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis (Third Edition). Wiley – Inter science, New York.
2. Morrison, D.F. (2004). Multivariate Statistical Methods (Fourth Edition). Duxbury Press, New York.

Books for Reference

1. Johnson, R.A. and D.W. Wichern. (2013). Applied Multivariate Statistical Analysis (Sixth Edition), Pearson New International Edition. 2. Kendall, M.G., Stuart, A. and Ord, K.J. (1973). The Advanced Theory of Statistics. (Fourth Edition), Vol. 2, Charles Griffin company Ltd.
3. Kotz, S., Balakrishnan, N. and Johnson, N.L. (2000). Continuous Multivariate Distribution Models and Applications (Second Edition). Volume 1, Wiley - Inter science, New York.
4. Mardia, K.V., Kent, J. T and Bibby, J. M. (1979). Multivariate Analysis. Academic Press, New York.
5. Rao, C.R. (2001). Linear Statistical Inference and its Applications (Second Edition), Wiley-Inter Science, New York.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3C09**
Title of the paper		**Multivariate Analysis**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.3: DEMOGRAPHIC METHODS

Semester	**III**
Paper code	**18UPSTA3C10**
Paper title	**Demographic Methods**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

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

1. To familiarize with active research projects in Demography and to improve skills in R.
2. Topics covered include demographic with the Human Mortality Database, Fertility and Migration.
3. Identify and compare the advantages and disadvantages of the different sources of demographic data
4. Define and differentiate the demographic concepts, terminology and formulas.
5. Construct and analyze simple and abridged life-tables

6. Derive the mathematical relationships in a cohort life table.
7. Estimate the rate of change in a population
8. Recognize and analyze typical demographic patterns arising from the data.
9. Present appropriate techniques to ensure comparability of the measures across population.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Measurement of mortality by age and cause.
- ✓ Current trends and differentials by age, sex, race, occupation and marital status.
- ✓ Consequences of mortality declines for fertility change and development.
- ✓ Fertility trends and it affects the population growth.
- ✓ Migration issues and importance on Government planning and execution of policies.

Unit I: Demography:

Demography: Meaning, scope and its development, demographic data and their sources - Current status - Chandrashekar - Deming index - Adjustment of age data – Population size and growth in India - Trends and differentials in world population. – Health Surveys and use of hospital statistics – Population transition theory.

Unit II: Mortality:

Mortality - Basic measurements - Crude, specific, standardized death rates - Life table - construction, use and interpretation - force of mortality - abridged life tables.

Unit III: Fertility:

Fertility - Basic measurements - Gross and Net Reproduction rate - Cohort fertility analysis - Fertility models - Population regulation programs in India - Demographic transition theory.

Unit IV: Special Distribution of Population:

Special distribution of population - basic concepts - measurements and models of migration - concept of international migration - Urban development, components of urban and metropolitan growth - Urbanization in developed and developing countries - Stable and quasi populations- Intrinsic growth rate.

Unit V: Population study:

Components of population growth and change – Models of population growth and their filling to population data - Methods of projection - Logistic equation and fitting - component method of projection - stable population theory – Decennial population census in India – Nuptiality and its measurements.

Books for Study and Reference

1. Benjamin, B. (1975). Demographic Analysis. George Allen and Unwin Limited.
2. Cox, P.R. (1978). Demography (Fifth Edition).Cambridge University Press.

Books for Study and Reference

1. Bogue, D. J. (2007). Principles of Demography, Wiley, New York.
2. Gibbs, J.P. (2012). Urban Research Methods.Literary Licensing, LLC.

3. Keyfitz, N. and Caswell, H. (2006). Applied Mathematical Demography. Springer lag, New York.
4. Kumar, R. (1986). Technical Demography. John Wiley & Sons, Canada.
5. Misra, B.D. (1982). An Introduction to the Study of Population, South East Asia Publishers, New Delhi.
6. Spiegelman, M. (1969). Introduction to Demographic Analysis.Harvard University Press.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3C10**
Title of the paper		**Demographic Methods**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 3.4: ECONOMETRICS

Semester	**III**
Paper code	**18UPSTA3C11**
Paper title	**Econometrics**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. The student will have a deeper understanding of economic statistics, econometrics, and have greater confidence in its application.
2. Students will learn the basics of ordinary least squares model estimation, with its advantages and disadvantages.
3. Students will learn appropriate alternatives to ordinary least squares, when assumptions underlying the classical linear regression model are violated.
4. Students will learn model construction and estimation, with applications in consumer and producer theory.
5. Students will gain insights into the relationship between econometric estimation and diagnostic testing.
6. Students will understand the basics of micro-econometrics and time series.

Course outcomes

Having successfully completed this module you will be able to:
- ✓ A broad knowledge of regression analysis relevant for analyzing economic data.

- ✓ interpretation and critical evaluation of the outcomes of empirical analysis
- ✓ Elementary procedures for model validation in the single equation context.
- ✓ Theoretical background for the standard methods used in empirical analyses, like properties of least squares estimators and the statistical testing of hypothesis.

Unit I:
Nature and Scope of Econometrics - Single Equation Regression Models – Ordinary least square (OLS) Method of Estimation and Prediction - Precision of OLS Estimates - Properties of Estimates under Normality Assumption - Dummy Variables: Nature and Use – Caution - Generalized least square (GLS) Method of Estimation and Prediction- Two variables only.

Unit II:
Homoscedasticity and Heteroscedasticity: Nature – OLS Estimation and Its Consequences – Detection: Informal and Formal Methods (Park, Goldfeld and Quandt test) - Remedial Measures – Method of GLS. Concept of Multicollinearity: Effects, Detection and Remedial Measures - Problem of Aggregation.

Unit III:
Concept of Autocorrelation: OLS Estimation – BLUE - Consequences of Using OLS – Tests for Detection – Remedial Measures – GLS. Ridge Regression - Autoregressive and Distributed Lag Models: Estimation of Models – Method of Instrumental Variables – Autocorrelation in Autoregressive Models – Durbin h test.

Unit IV:
Simultaneous Equation Model: Nature and Illustrations - Simultaneous Equation Bias -Problem of Identification – Under and Over Identification - Rules for Identification: Order and Rank Conditions of Identifiability - Test of Simultaneity – Test for Exogeneity.

Unit V:
Simultaneous Equation Model: Approaches to Estimation Recursive Models and OLS Estimation of an Identified Equation: Method of Indirect Least Squares. Estimation of an over-identified Equation: Method of Two-stage and Three-stage Least Squares Estimation – Method of Maximum Likelihood Estimation. Monte Carlo studies and simulation for Model specification.

Books for Study

1. Gujarati, D. N., Dawn C Porter and SangeethaKunasekar, (2016), Basic Econometrics, Fifth Edition, McGraw Hill Publisher, New York.

Books for Reference

1. Castle, J. and Shephard, N. (2009). The Methodology and Practice of Econometrics. OUP Oxford Publications.
2. Goldberger, A.S. (1964): Econometrics theory. John Wiley & Sons, New Delhi.
3. Johnston, J., and J. DiNardo,.(1997). Econometric Methods, McGraw-Hill.
4. Kelejion, H.H. and Oates, W.E. (1988). Introduction to Econometrics: Principles and Applications. Harper and Row Publishers Inc., New York.
5. Khotsoyiannis, A. (1977). Theory of Econometrics. Second Edition, Macmillan.

6. Maddala, G.S. and Lagari, K. (2009). Introduction to Econometrics. John Wiley & Sons, New York.
7. Madnani, G.M.K. (2008). Introduction to Econometrics: Principles and Applications. Oxford and IBH Publishing.
8. Wooldridge, J. (2012). Introduction Econometrics: A Modern Approach. Cengage Learning.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3C11**
Title of the paper		**Econometrics**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 3.5.1: CATEGORICAL DATA ANALYSIS

Semester	**III**
Paper code	**18UPSTA3E07**
Paper title	**Categorical Data Analysis**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. Mathematical concepts and principles to perform numerical and symbolic computations.
2. Use technology appropriately to investigate and solve mathematical and apply statistical problems.
3. Write clear and precise proofs.
4. Communicate effectively in both written and oral form.
5. Demonstrate the ability to read and learn mathematics and/or statistics independently.

Course outcomes

Having successfully completed this module you will be able to:
- ✓ give an account of the sampling strategies for categorical data;
- ✓ analyze a two-way contingency table;
- ✓ carry out exact inference for a three-way contingency table;
- ✓ build and apply logit and log linear models;
- ✓ use R for analysing real data sets;
- ✓ Be able to interpret the results in practical examples.

Unit I

Models for Binary Response Variables, Log Linear Models, Fitting Log linear and Logic Models-Building and applying Log Linear Models, Log- Linear - Logit Models for Ordinal Variables.

Unit II

Multinomial Response Models - Models for Matched Pairs- Analyzing Repeated Categorical Response Data - Asymptotic Theory for Parametric Models - Estimation Theory for Parametric Models.

Unit III

Classical treatments of 2 and 3-way contingency tables, measures of association and nonparametric methods - Generalized linear models - Logistic regression for binary - multinomial and ordinal data – Log - linear models - Poisson regression- Modeling repeated measurements- generalized estimating equations.

Unit IV

Introduction to contingency tables: 2×2 and r×c tables - tests for independence and homogeneity of proportions - Fishers exact test - Odds ratio and Logit, other measures of association - Introduction to 3 - way tables – full independence and conditional independence - collapsing and Simpsons paradox.

Unit V

Polytomouslogit models for ordinal and nominal response- Log-linear models (and graphical models) for multi-way tables - Causality, repeated measures, generalized least squares - mixed models, latent-class models, missing data, and algebraic statistics approach.

Books for Study and Reference

1. Agresti, Alan (1996). An Introduction to Categorical Data Analysis, Wiley.
2. Bergsma, W., Croon, M.A. and Hagenaars, J.A. (2009). Marginal Models: For Dependent, Clustered, and Longitudinal Categorical Data. Springer.
3. Bishop, Y.M., Fienberg, S.E. and Holland, P.W. (1975). Discrete Multivariate Analysis: Theory and Practice, MIT Press.
4. Edwards, D. (2000). Introduction to Graphical Modeling (Second Edition).Springer.
5. Fienberg, S.E. (1980). The Analysis of Cross-Classified Categorical Data.MIT Press.
6. Wasserman, L. (2004).All of Statistics: A Concise Course in Statistical Inference. Springer.
7. Whittaker, J. (1990). Graphical Models in Applied Multivariate Statistics.Wiley.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3E07**
Title of the paper		**Categorical Data Analysis**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.5.2: STATISTICAL METHODS FOR EPIDEMIOLOGY

Semester	**III**
Paper code	**18UPSTA3E08**
Paper title	**Statistical Methods for Epidemiology**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Identify key sources of data for epidemiologic purposes.
2. Identify the principles and limitations of public health screening programs.
3. Describe a public health problem in terms of magnitude, person, time and place.
4. Explain the importance of epidemiology for informing scientific, ethical, economic and political discussion of health issues.
5. Comprehend basic ethical and legal principles pertaining to the collection, maintenance, use and dissemination of epidemiologic data.
6. Apply the basic terminology and definitions of epidemiology.
7. Calculate basic epidemiology measures.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

1. Explain the key features of epidemiological studies and what distinguishes them from other types of studies
2. Explain how the design features of the different types of studies dictate the methods of analysis appropriate to each.
3. Explain the different measures of disease occurrence and calculate these measures.
4. Explain the concepts of causality, confounding, and interaction.

5. Examine whether interaction and/or confounding is present in an epidemiological study.
6. Implement techniques to deal with interaction and/or confounding in an epidemiological study.
7. Explain the different types of regression models used in epidemiological studies.

Unit I

Measures of disease frequency: Mortality/Morbidity rates- incidence rates- prevalence rates - Source of mortality morbidity statistics-hospital records - vital statistics records- Measures of accuracy or validity: sensitivity index - specificity index- Measure of Reliability.

Unit II

Epidemiologic concepts of diseases: Factors which determine the occurrence of diseases - models of transmission of infection - incubation period - disease spectrum and herd immunity.

Unit III

Observational studies in Epidemiology: Retrospective (case control) and prospective (cohort or longitudinal) studies - Measures of association: Relative risk, odds ratio, attributable risk- Statistical techniques used in analysis: Cornfield and Gartsmethod - Mantel-Haenszelmethod- Conditional and unconditional matching - Analysis of data from matched samples, logistic regression approach.

Unit IV

Experimental Epidemiology: Clinical & community trials - Statistical Techniques: Methods for comparison of two treatments - Crossover design with Garts and McNemars test - Randomization in a clinical trial - sequential methods in clinical trials - clinical life tables - assessment of survivability in clinical trials.

Unit V

Mathematical Modeling in Epidemiology:(deterministic and stochastic) simple epidemic model - generalized epidemic model- Reed-Frost and Green-wood models - models for carrier borne and host vector diseases - Estimation of latent and infectious periods - geographical spread of the disease - simulation of an epidemic.

Books for Study

1. Roger D. Peng Francesca Dominici, (2008), Statistical Methods for Environmental Epidemiology with R, Springer.
2. David G. Kleinbaum, Mitchel Klein (2002). Logistic regression- A self-learning approach- Springer.

Books for Reference

1. Armitage. (1980). Sequential medical trials, Charles C. Thomas
2. Bailey, N.T.J. (1987). The Biomathematics of Malaria.Oxford University Press, Incorporated.
3. Fleiss, J.L. (1981): Statistical Methods for Rates and Proportions. John Wiley& Sons, Incorporated, New York.
4. Franeuthal. (1980). Mathematical Modernization in Epidemiology, Springer Verlag.
5. Gross and Clark. (1989). Survival Distributions- Reliability Application in Biomedical Sciences, University Microfilms.

6. Kahn, H.A. and C.T. Sempos. (2007). Statistical Methods in Epidemiology (Second Edition).Oxford University press, N.Y.
7. Kahn, H.A. (1983): An introduction to Epidemiologic methods. Oxford University press, N.Y. (Digitized 2007).
8. Lilienfeld and Lilenfeld. (1994): Foundations of Epidemiology (Third edition). Oxford University Press.
9. Macmahon, B. and Pugh, T.E. (1970). Epidemiology-Principles and methods, Little, Brown and Co. Boston/Massachusetts.
10. Pocock, S.J. (2004). Clinical Trials - A Practical Approach, John Wiley.
11. Fletcher, R. andFletcher, S.W. (2013). Clinical Epidemiology: The essentials. Lippincott Williams & Wilkins.
12. Rothman, K.J. (1986): Modern Epidemiology. Lippincott Williams & Wilkins.
13. Sackett, D. L (1991). Clinical Epidemiology - A Basic Science for Clinical Medicine.Little Brown.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3E08**
Title of the paper		**Statistical Methods for Epidemiology**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.5.3: STATISTICAL DATA ANALYSIS USING R

Semester	**III**
Paper code	**18UPSTA3E09**
Paper title	**Statistical Data Analysis Using R**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. Introduction to data science life cycle
2. In depth knowledge of most popular machine learning techniques
3. Supervised and unsupervised learning techniques
4. Real life case studies and simulated projects to sharpen your skill sets
5. Assistance in creating a portfolio which will allow you to showcase your newly acquired skills.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

1. Understanding and implementing Linear Mixed Models (LMM).
2. Implementation of statistical procedures within the R environment.
3. Data manipulation - acquiring skills in flexible matrix manipulation.
4. Scripting - programming an analysis in such a way that the script can be used with minimal effort for similar datasets and analyses and for especially large datasets.
5. Data visualization - learning how to create high-quality figures, especially associated with more complex analyses (e.g. three dimensional scatter plots, Trellis displays, etc.).

Unit I:

Data types in *r* numeric/character/logical; real/integer/complex strings and the paste command matrices, data frames, lists, setwd, read, table, read, csv, write. matrix, write. csv, creation of new variables, categorization, cut, factor; round, apply, creation of patterned variables - saving output to a file; source; print -saving workspace / history.

Unit II:

Graphics in *r* - the plot command, histogram, bar plot, box plot - points, lines, segments, arrows, paste - inserting mathematical symbols in a plot, pie diagram, customization of plot-setting graphical parameters - text and mtext, the pairs command, colours and palettes, saving to a file; graphical parameters such as mar/mai/mfrow,xlab/ylab/las/xaxp/yaxp/xlim/ylim/cex/axis/tck/srt,main/title/leg end/locator, identify.

Unit III:

Basic statistics - *r* help-command help, help.search(), *r* mailing list - contributed documentation on cran - one and two sample *t* tests, Bartlett's test for variance, *f* - test for equality of variances, multi sample means, non-parametric tests, chi-squared tests - randomness, homogeneity, independence, exact tests and confidence intervals, checking the assumptions, distribution fitting.

Unit IV:

Vector matrix operations - matrix operations - addition, subtraction, multiplication, linear equations and eigenvalues, matrix decomposition - lu, qr and svd and inverse, the linear model and qr decomposition, determinant, g inverse, finding a basis, orthonormalization, finding rank, the lm function; fitting a linear model; ANOVA / ANCOVA / regression.

Unit V:

Linear models - models, the summary function, goodness of fit measures, predicted values and residuals; residual plots, the ANOVA table, creating factors - *r* functions - random number generation and simulations - *r* libraries.

Books for Study and Reference

1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009).Statistics Using R, Narosa Publishing House, New Delhi.
2. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK.

3. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall, CRC Press.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3E09**
Title of the paper		**Statistical Data Analysis Using R**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.6.1: DESCRIPTIVE STATISTICS

Semester	**III**
Paper code	**18UPSTA3S01**
Paper title	**Descriptive Statistics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Describe statistical measures used in descriptive statistics
2. Help us to explain the distribution of data in terms of center and variability.
3. Be able to compute and interpret the expected value, variance, and standard deviation for a discrete random variable
4. Identify and differentiate between absolute and relative error.
5. Demonstrate knowledge of probability and the standard statistical distributions.
6. Understand the ability to apply linear, nonlinear and generalized linear models
7. Understand the difference between how probabilities are computed for discrete and continuous random variables.
8. Interpret the Pearson correlation coefficient and the coefficient of determination, and test for significance.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Descriptive Statistics, tools that they are confronted with on a daily basis through the media, which use them to excess.
- ✓ Analyze statistical data graphically using frequency distributions and cumulative frequency distributions.
- ✓ Analyze statistical data using measures of central tendency, dispersion and location.

- ✓ Organize, manage and present data.

Unit I: Basics of Statistics:
Origin - Scope – Functions - limitations - uses and misuses of statistics – Collection of Data - Classification and Tabulation of data - Diagrammatic and Graphical representation of data.

Unit II: Measures of dispersion:
Measures of Central tendency - Measures of Dispersion - Relative measures of dispersion - skewness and kurtosis - Lorenz curve-Simple problems.

Unit III: Sampling and Probability:
Elementary probability space - Sample space - discrete probability, independent events - Mathematical and Statistical probability - Axiomatic approach to probability - Addition and multiplication theorems - conditional probability – Bayes' theorem - Simple problems.

Unit IV: Random Variables:
Random variables - Discrete and continuous random variables - Distribution function – probability mass function and probability density function of a random variable - Expectation of a random variable.

Unit V: Simple Linear Correlation and Regression:
Simple linear correlation and regression - Scatter diagram - Karl Pearson's correlation coefficient and its properties - Spearman's correlation co-efficient.Regression equations - Fitting of regression equations - Regression coefficients and its properties.

Books for Study

1. Gupta, S.C. and V.K. Kapoor. (2000). Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.

Books for References

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2008). Fundamentals of Statistics, Vol.I, World Press Ltd, Calcutta.
2. Gupta, S.C. and V.K. Kapoor. (2000). Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi.
3. Hogg, R.V., McKean, J.W. and Craig, A.T. (2013). Introduction to Mathematical Statistics, (Seventh Edition), Pearson Education Ltd.
4. Spiegel, M.R., Schiller, J. and Srinivasan, R.A. (2012). Probability and Statistics, Schaum's Outline Series (Fourth Edition), McGraw- Hill Publishing Company, New Delhi.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3S01**
Title of the paper		**Descriptive Statistics**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.6.2: COMPUTER ORIENTED STATISTICAL METHODS

Semester	**III**
Paper code	**18UPSTA3S02**
Paper title	**Computer Oriented Statistical Methods**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. To learn fundamentals and concepts of statistical and optimization methods, in particular, with reference to frequency distribution and measures of central tendency, measures of dispersion, skewness and kurtosis,
2. To solve problems on theory of probability, linear programming problems, transportation, assignment and game problems.
3. To learn important theorems, different formulae and practical applications of these statistical and optimization methods in the field of Computer Sciences and Applications.

Course outcomes

Upon completion of the course students shall be able to:

- ✓ Recognize the error in the number generated by the solution.
- ✓ Compute solution of algebraic and transcendental equation by numerical methods like Bisection method and Newton Rapshon method.
- ✓ Apply method of interpolation and extrapolation for prediction.
- ✓ Recognize elements and variable in statistics and summarize qualitative and quantitative data.
- ✓ Calculate mean, median and mode for individual series.

- ✓ Outline properties of correlation and compute Karl-Pearson's coefficient of correlation.

Unit I: Descriptive statistics:
Introduction to Computing - Computer Codes and Arithmetic Overview of BASIC - Sampling and Frequency Distribution - Measures of Central Tendency - Measures of Dispersion - Moments - Computation of Moments – Simple Problems.

Unit II: Discrete Probability Distribution:
Discrete Probability Distributions: Probability - Characteristics of Probability - Discrete Distributions - Binomial Distribution - Poisson Distribution - Hypergeometric Distribution – Properties and Numerical problems.

Unit III: Curve Fitting:
Curve Fitting: Linear Regression - Least Squares Fit - Nonlinear Fit - Fitting a Polynomial Function.

Unit IV: Correlation and Its properties:
Correlation : Coefficient of Correlation - Properties of Correlation Coefficient - Rank Correlation - Multiple Correlation - Partial Correlation.

Unit V: Test of Significance:
Tests of Significance: Small sample and large sample tests - t Test, F Test and x^2 test - ANOVA one way and two way classifications simple problems using Excel.

Books for Study

1. Balagurusamy, E. (2000): Computer Oriented Statistical and Numerical Methods, Macmillan Publishers India Limited.
2. Enslein, K., Ralston, A., and Wilf, H.S. (1976): Statistical Methods for Digital Computers. John Wiley & Sons, New York.

MODEL BLUEPRINT		
Subject Code		**17UPSTA1S02**
Title of the paper		**Computer Oriented Statistical Methods**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.6.3: STATISTICS FOR ECONOMICS

Semester	**III**
Paper code	**18UPSTA3S03**
Paper title	**Statistics for Economics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Skills in describing, analyzing and interpreting statistical data
2. Understanding of the principles and assumptions on which these procedures are based
3. The ability to analyze statistical data using MS Excel
4. The ability to relate statistical methodology to economic enquiry.

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Use graphical and numerical methods to calculate and illustrate descriptive statistics
- ✓ Use the basic concepts of probability and Bayes Theorem
- ✓ Identify the statistical concepts in questions about economic models
- ✓ Identify the appropriate regression model to apply to an economics dataset
- ✓ Identify common problems which may affect regression analyses.

Unit I

Nature and scope of statistics - characteristics and limitation of statistics - statistical investigation - preparation of questionnaire - design of sampling - simple random, stratified and systematic sampling - collection of data - primary and secondary data.

Unit II

Processing and presentation of data - Classification of data - tabulation of data - Formation of frequency tables - Diagrammatic presentation of statistical data - bar diagrams - pie diagrams and pictograms - simple problems – Graphical presentation of statistical data - Histogram, frequency curves and Ogive curve- simple problems.

Unit III

Measures of central tendency - mean, median, mode - simple problems - measures of dispersion - range, mean deviation, quartile deviation and standard deviation - relative measures of dispersion - simple problems - Concept of Skewness and Kurtosis - Karl Pearson's and Bowley's coefficients of Skewness- moments- coefficients of Skewness and Kurtosis - simple problems.

Unit IV

Correlation: Scatter diagram - simple correlation, Rank correlation - Regression - simple regression lines (without proof) - Tetrochoric correlation, Phi coefficient and Kendall's co-efficient - simple problems.

Unit V

Time Series – Components of time series – Trend, Seasonal, cyclical, random variations – Methods of measuring trend and seasonal variations - Index Numbers – Meaning and uses - Cost of living index numbers – Construction of Consumer's price index numbers – Wholesale price index numbers.

Books for Reference

1. Agarwal, B. L. (2006). Basic Statistics, New Age International, New Delhi.
2. Goon, A. M., Gupta, M. K., and Dasgupta, B. (2008). Fundamentals of Statistics, Vol.I, World Press Ltd, Calcutta.
3. Gupta, S.C., and Kapoor, V. K. (2000). Fundamentals of Mathematical Statistics, Tenth Edition. Sultan Chand and Sons, New Delhi.
4. Gupta S. C., and Kapoor, V. K. (2014). Fundamentals of Applied Statistics, Fourth Edition, Sultan Chand and Sons, New Delhi.
5. Saxena, H.C. (1967). Elementary Statistics, Sultan Chand & Co., New Delhi.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3S03**
Title of the paper		**Statistics for Economics**
Unit Number	**Statistics for Economics**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.6.4: MATHEMATICAL ECONOMICS

Semester	**III**
Paper code	**18UPSTA3S04**
Paper title	**Mathematical Economics**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Elasticity of Demand - Total, Average and Marginal Cost Curves - Relation between Average and marginal Cost Curves - Minimum Average cost-Cost function in Cubic Form - Total Average - Marginal Revenue Curves - Total Revenue.
2. Maximization of Utility - Income and substitution Effects – Important Results from Slutsky Equation - Elasticity form of Slutsky Equation.

Course outcomes

After successfully completing the course, a student should be able to demonstrate…

- ✓ Use graphical and numerical methods to calculate and illustrate descriptive statistics.
- ✓ Use the basic concepts of Mathematical Economics.
- ✓ Identify the statistical concepts in questions about economic models.
- ✓ Identify the appropriate regression model to apply to an economics dataset.
- ✓ Identify common problems which may affect regression analyses.

Unit I

Elasticity of Demand - Total, Average and Marginal Cost Curves - Relation between Average and marginal Cost Curves - Minimum Average cost-Cost function in Cubic Form - Total Average - Marginal Revenue Curves - Total Revenue - Conditions for Profit Maximization - Effects of Taxation and Subsidy on monopoly.

Unit II

Indifference Curve - Rate of Commodity substitution (RCS)-Maximization of Utility - Income and substitution Effects – Important Results from Slutsky Equation - Elasticity form of Slutsky Equation.

Unit III

Production Function - Constant Product Curves: Isoquants - Shape of Isoquants and Ridge Lines-Least Cost Combination (constrained Cost Maximisation) - Constrained Profit Maximization - Homogeneous Function - Cobb-Douglas production function - Elasticity of substitution- Elasticity of substitution of Linearly Homogeneous Function - C.E.S. Function.

Unit IV

Multiple Production by Monopolist - Discriminating monopoly -Duopoly - Consumer's Surplus - Producer's Surplus.

Unit V

Input-Output Analysis: Assumptions – Closed and open Input-Output model - coefficient Matrix and Open model - Leontief Model - Alternative Way for Inverting the Leontief Matrix - Interpretation of the Alternative Formulation - Coefficient Matrix and closed model - Consumption function - Dynamic Input Output model - Possible Weaknesses and Limitations of Input-Output Analysis.

Books for Reference

1. Allen, R.G.D. (2008). Mathematics for Economists, ELBS series, London.
2. Daus, P.H., and Whyburn, W.M. (1962). Mathematics for Economists, Addison and Wesley, Amsterdam.
3. Draper, J., and Klingman, J. (1972). Mathematical Analysis: Business and Economic Applications, Harper – Row publishing company.
4. Henderson, J.M., and Quandt, R.E. (1967). Micro Economic theory, McGraw- Hill.
5. Mehta, B C., and Madnani, G.M.K.(1977). Mathematics for Economists (Third Edition), Sultan Chand, New Delhi.
6. Tintner, G. (1966). Mathematics and Statistics for Economists, Holt, Rinehart and Winston, Inc.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3S04**
Title of the paper		**Mathematical Economics**
Unit Number	**Statistics for Economics**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 3.7: STATISTICS PRACTICAL USING R-I

Semester	**III**
Paper code	**18UPSTA3P03**
Paper title	**Statistics Practical Using R-I**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Introduction – introduce the practice of data science and the R programming language.
2. Working with Data – learn how to import, transform, clean, and export data.
3. Descriptive Statistics – learn how to create and interpret univariate and bivariate statistics.
4. Data Visualization – learn how to create univariate, bivariate, and multivariate data visualizations.

5. Statistical Modeling – learn to create Gaussian models and simple linear regression models.
6. Handling Big Data – learn about big data and how to handle it with tools in R.
7. Machine Learning – learn about ML and how to train, test, and implement ML models.
8. R in Practice – learn about R in production, reproducible research, and industry best practices.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…
1. List motivation for learning a programming language.
2. Access online resources for R and import new function packages into the R workspace.
3. Import, review, manipulate and summarize data-sets in R.
4. Explore data-sets to create testable hypotheses and identify appropriate statistical tests.
5. Perform appropriate statistical tests using R.
6. Create and edit visualizations with R.

Exercise under Descriptive Statistics, Correlation, Regression and Test of significance.

1. Calculate the descriptive Statistics.
2. Calculate the correlation coefficient.
3. Calculate the regression equations.
4. Calculate multiple regressions.
5. Calculate the logistic regression equations.
6. Problems for the one sample *Z* – test for mean and proportion.
7. Problems for the two samples *Z* - test for mean and proportion.
8. Problems for the paired *t*-test.
9. Problems of t test for mean for one sample and two samples.
10. Problems of F test for equality of variances
11. Problems for the chi-square test independence of attributes.
12. Problems for the chi-square goodness of fit test.

MODEL BLUEPRINT		
Subject Code		**18UPSTA3P03**
Title of the paper		**Statistics Practical Using R-I**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER IV

AIMS

1. To provide a broad based high quality education with combination of the subjects like Linear models and Design of experiments, Stochastic Processes, Applied Regression Analysis, Time series Analysis and Bayesian Methods, Statistical Software Practical and Project Viva-voce to Post-Graduate Degree level for students who have to demonstrate their ability and potential towards Statistical Theory and Applications.
2. To develop knowledge, understanding and experience of the theory, practice and application of selected areas of statistical computing and to produce graduates needed by public and private sector to help and solve practical problems using the skills and techniques of these areas and to develop analytical skills for Insurance Sector.
3. To develop enterprise competences emphasizing the key skills of learning and communication for Statistical theory.

OBJECTIVES

1. An understanding of the Statistical principles, techniques and applications of selected areas of Statistics and computing.
2. The ability to evaluate, select, write and use of computer software packages for Statistical theory which takes into account the needs of the user and constraints towards computing environment.
3. The ability and confidence to analyze and solve problems both of a routine and of obvious nature towards applications of Statistical theory.
4. To gain deeper understanding, problem solving skills and greater knowledge of selected topics in Statistical computation.

SEMESTER4.1: LINEAR MODELS AND DESIGN OF EXPERIMENT

Semester	**IV**
Paper code	**18UPSTA4C12**
Paper title	**Linear Models and Design of Experiment**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives:

Upon successful completion of this course, the students will be able to:
1. Develop factorial and fractional factorial designs for product and process optimization.
2. Design and conduct orthogonal array experiments for process improvement.
3. Illustrate robust design concepts.

Course outcomes:

After the successful completion of the course, the students will be able to:
- ✓ Remember the basic terms as used and applied in the context of design of experiments
- ✓ Understand the process of developing strategic plans for experimentation in scientific and engineering research projects.
- ✓ Apply the principles of DoE to generate experimental designs.
- ✓ Analyze alternative designs for experimentation and carry out output analysis for quality improvement projects.
- ✓ Evaluate the performance of the research investigations based on factorial and fractional factorial de signs.
- ✓ Create experimental designs for product and process quality improvement projects for various scientific and engineering applications.

Unit I: Linear Models

Linear models – Definition – Fixed, Random and mixed effects models - Estimability of a linear parametric function - Best Linear Unbiased Estimator – Gauss - Markov theorem - The General GuassMarkoff model.

Unit II: Analysis of Variance

Analysis of variance for one – way and two - way classification with one and more than one (equal) observations per cell with interaction - Analysis of covariance (ANCOVA) - description of the method in the case of one and two concomitant variables.

Unit III: Principles of Design

Fundamental principles of design of experiments - Randomization, Replication and Local control - Completely Randomized Design(CRD) - Randomized Block Design(RBD) - Latin Square Design (LSD) and their analyses - Missing plot technique for RBD and LSD – one and two missing observations - Graeco - LSD - Analysis.

Unit IV: Concepts of Experiment

Factorial experiments – 2^3 and 3^3 experiments and their analysis – Construction complete and partial confounding - (2×3) and (3×4) Asymmetrical Factorial Experiment Analysis - Fractional replication designs - Salient Features - Construct of $\frac{1}{2}(2^5)$ and $\frac{1}{2}2^6$ Fractional replication designs - Split-plot and Strip-plot designs.

Unit V: Concepts of BIBD

Incomplete block design - Balanced incomplete block design and partially balanced incomplete block design with two associate classes-parametric relation and analysis - Youden square design - concept and analysis - Concept of Lattice design.

Books for Study

1. Das, M. N. and Giri, N. S. (1986). Design and Analysis of Experiments (2nd Edition). Wiley Eastern Ltd., New Delhi.

Books for Reference

1. Cochran, W. G and Cox, G. M. (1957). Experimental Design.John Wiley &sons, New York.
2. Dey, A. (2010). Incomplete Block Design.World Scientific Publishing Company.
3. Fisher, R. A. (1953). Design and Analysis of Experiments. Oliver and Boyd, London.
4. Giri, N.C. (1986). Analysis of Variance. South Asian Publisher, New Delhi.
5. John,P.W.M (1998). Statistical Design and Analysis Experiments.Macmillan Company, New York.
6. Joshi, D.D (1987). Linear Estimation and Design of Experiments, New Age International (P) Ltd. New Delhi.
7. Kempthorne, O. (1976). Design and Analysis of Experiments. John Wiley & Sons, New York.
8. Montgomery, D.C. (2012). Design and analysis of Experiments. John Wiley & Sons, New Delhi.
9. Panneerselvam, R. (2012). Design and Analysis of Experiments, Prentice Hall.
10. Searle, S.R. (2012). Linear Models. John Wiley & Sons, Inc., New York.
11. Rangaswamy R, (2006), Agricultural Statistics, New age international Pvt.` New Delhi.
12. ParimalMukhopadhaya, (2011), Applied Statistics, Books & Allied Ltd; 2nd revised edition.

MODEL BLUEPRINT		
Subject Code		**18UPSTA4C12**
Title of the paper		**Linear Models and Design of Experiment**
Unit Number	Number of hours	Total Marks
1	12	30
2	12	30
3	12	30
4	12	30
5	12	30
Total	60	75
Maximum marks for the paper		75

SEMESTER 4.2: STOCHASTIC PROCESSES

Semester	**IV**
Paper code	**18UPSTA4C13**
Paper title	**Stochastic Processes**
Number of teaching hrs per week	**4**
Total number of teaching hrs per semester	**60**
Number of credits	**4**

Learning objectives

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

1. Be able to work with stochastic processes such as Poisson process and Brownian Motion.
2. Check if a given process is stationary or not; derive auto-covariance function; learn about Gaussian processes.
3. Learn about discrete-time Markov Chains; derive limiting state probabilities for a finite Markov Chain; and evaluate stationary probabilities for Ergodic Markov chains.

Course outcomes

On successful completion of the course, a student should be able to demonstrate…

- ✓ The student has basic knowledge about stochastic processes in the time domain.
- ✓ The student has acquired more detailed knowledge about Markov processes with a discrete state space, including Markov chains, Poisson processes and birth and death processes.
- ✓ The student also knows about queing system and Brownian motion, in addition to mastering the fundamental principles of simulation of stochastic processes and the construction of Markov chain Monte Carlo (MCMC) algorithms.

Unit I: Introduction of Stochastic Process:
Introduction to Stochastic Processes Classification of Stochastic Processes, Markov Processes Markov Chain Countable State Markov Chain.Transition Probabilities, Transition Probability Matrix. Chapman - Kolmogorov's Equations, Calculation of n - step Transition Probability and its limit.

Unit II: Differential Equations:
Classification of States, Recurrent and Transient States -Transient Markov Chain, Random Walk and Gambler's Ruin Problem. Continuous Time Markov Process: Poisson Processes, Birth and Death Processes, Kolmogorov's Differential Equations, Applications, Properties.

Unit III: Branching Processes:
Branching Processes –Galton –Watson Branching Process -Properties of Generating Functions – Extinction Probabilities –Distribution of Total Number of Progeny.Concept of Weiner Process.

Unit IV: Renewal Processes:
Renewal Processes – Renewal Process in Discrete and Continuous Time – Renewal Interval – Renewal Function and Renewal Density –Renewal Equation – Renewal theorems: Elementary Renewal Theorems. Probability Generating Function of Renewal Processes.

Unit V: Time Series Applications:
Stationary Processes Application to Time Series – Auto covariance and Autocorrelation functions and their properties. Moving Average, Autoregressive, Autoregressive Moving Average, Autoregressive Integrated Moving Average Processes. Basic ideas of residual analysis, diagnostic checking, forecasting.

Books for Study
1. Medhi, J. (2017). Stochastic Processes, Fourth Edition, New Age International (P) Ltd. New Delhi.

Books for Reference
1. Bhat, B. R. (2000). Stochastic Models: Analysis and Applications, New Age International (P) Ltd.
2. Bhat, U. N., and Miller, G. K. (2002). Elements of Applied Stochastic Processes, Third Edition, Wiley -Interscience.
3. Box, G.E.P., and Jenkins, G.M., (1976). Time Series Analysis - Forecasting and Control. Holden-Day San Francisco.
4. Karlin,S. and Taylor,H.M. (1975). A First Course in Stochastic Process, Second Edition, Academic Press.
5. Parzen, E. (1962). Stochastic Processes, Holland-Day

MODEL BLUEPRINT		
Subject Code		**18UPSTA4C13**
Title of the paper		**Stochastic Processes**
Unit Number	**Number of hours**	**Total Marks**
1	12	15
2	12	15
3	12	15
4	12	15
5	12	15
Total	60	75
Maximum marks for the paper		75

SEMESTER 4.3.1: APPLIED REGRESSION ANALYSIS

Semester	**IV**
Paper code	**18UPSTA4E10**
Paper title	**Applied Regression Analysis**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. Develop a deeper understanding of the linear regression model and its limitations.
2. Know how to diagnose and apply corrections to some problems with the generalized linear model found in real data; discussed.
3. Use and understand generalizations of the linear model to binary and count data.
4. Develop a greater familiarity with a range of techniques and methods through a diverse set of theoretical and applied readings.

Course Outcomes

After successfully completing the course, a student should be able to demonstrate…
- ✓ The first objective is to provide a thorough foundation for simple linear regression as a tool for exploring the linear relationship between two variables.
- ✓ Students will learn how to estimate and interpret the model.
- ✓ Once students understand the model, they will explore how to evaluate the model.
- ✓ Students will also list the assumptions underlying the simple linear regression model and use graphical and numerical methods to check the assumptions.
- ✓ They will also use the model to estimate means and predict individual responses, and construct intervals for the estimates and predictions.
- ✓ Students will then move onto multiple linear regression where more than one predictor is included in the model.

- ✓ They will learn how estimation, evaluation, checking assumptions, estimating means, and predicting individual responses generalize to this setting.
- ✓ Students will learn about using variable transformations and interactions to incorporate nonlinear and nonadditive relationships in the model.
- ✓ Communicate the results of statistical analyses accurately and effectively.

Unit I: Simple Regression Model:
Simple regression models with one independent variable, assumptions, estimation of parameters, standard error of estimator, testing the significance of regression coefficients, standard error of prediction. Testing of hypotheses about parallelism, equality of intercepts, congruence - Extrapolation, optimal choice of independent variable.

Unit II: Diagnostic Check and Correction:
Diagnostic checks and correction: graphical techniques, tests for normality, uncorrelatedness, homoscedasticity, lack of fit, modifications like polynomial regression, transformations on Y or X. Inverse regression.

Unit III: Multiple Regression:
Multiple regression: Standard Gauss Markov Setup. Least square (LS) estimation, Error and estimation spaces. Variance - Covariance of LS estimators. Estimation of error variance, case with correlated observations.LS estimation with restriction on parameters.Simultaneous estimation of linear parametric functions.

Unit IV: Non-Linear Regression:
Non-linear regression: Linearization transforms, their use & limitations, examination of non-linearity initial estimates, iterative procedures for NLS grid search, Newton - Raphson, steepest descent, Marquardt's methods. Logistic Regression: Logic transform, ML estimation, Tests of hypotheses, Wald test, LR test, score test, test for overall regression.

Unit V: MLR and GLM Model:
Multiple logistic regressions, forward, backward method.Interpretation of parameters relation with categorical data analysis. Generalized Linear model: link functions such as Poisson, binomial, inverse binomial, inverse Gaussian and gamma.

Books for References

1. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, Third Edition, John Wiley and Sons.
2. Montgomary, D. C., Peck, E. A., and Vining, G. G. (2012). Introduction to Linear Regression Analysis, Fifth Edition, ohn Wiley and Sons.
3. McCullagh, P., and Nelder, J. A. (1989). Generalized Linear Models, Second Edition, Chapman& Hall.
4. Ratkowsky, D.A. (1983). Nonlinear Regression Modelling, Marcel Dekker.
5. Hosmer, D.W., Lemeshow, S., and Sturdivant, R. X. (2013). Applied Logistic Regression,

Third Edition, John Wiley and Sons.

6. Seber, G.E.F. and Wild, C.J. (2003). Nonlinear Regression, John Wiley and Sons.
7. Neter, J., Wasserman, W., and Kutner,M.H. (1989). Applied Linear Statistical Models, Second Edition, Irwin.

MODEL BLUEPRINT		
Subject Code		**18UPSTA4E10**
Title of the paper		**Applied Regression Analysis**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER 4.3.2: TIME SERIES ANALYSIS

Semester	**IV**
Paper code	**18UPSTA4E11**
Paper title	**Time Series Analysis**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

Upon successful completion of this course, the students will be able to:
1. Describe Components of Time Series
2. Understand the time dependency
3. Use exploratory tools : ACF, Periodogramme
4. Set thresholds
5. By accounting for time dependency by restriction
6. By regression modeling
7. By Box & Jenkins modeling

Learning outcomes

Having successfully completed this module you will be able to:
- ✓ Understand and be able to apply the concepts and methods underlying the analysis of univariate time series, and the context for interpretation of results
- ✓ Decompose a time series into trend, seasonal and irregular components
- ✓ Understand the theoretical bases of different methods of time series analysis including decomposition
- ✓ Determine how and when to apply different methods of time series analysis and how to test for goodness of fit using the software package X12.

Unit I:
Models of Time Series – Additive and Multiplicative models – Analysis and forecasting – Elimination of trend – growth curve – Modified experimental curve (Method of three selected points only) - Gompertz curve- Logistic curve with examples.

Unit II:
Stationary processes – Auto-covariance and autocorrelation functions and their properties – partial auto correlation function - Estimation of autocorrelation and its standard error – unit root test.

Unit III:
Linear stationary models - stationary and invertability - Autoregressive and Moving average processes and their autocorrelation functions- Autoregressive moving average processes. Linear non-stationary models - Autoregressive integrated moving average processes – integrated moving average processes and Seasonal Autoregressive integrated moving average processes.

Unit IV:
Box-Jenkins models: Identification techniques - Initial estimates for different processes – AR, MA, ARMA - choice between stationary and non-stationary models – model diagnostic - model multiplicity- Study of residuals and diagnostic checking - Use of computer packages for the above techniques.

Unit V:
Introduction to spectral analysis of weakly stationary processes - periodogram and correlogram analysis including computations based on Fourier transform. Use of spectral representation to show the existence of autoregressive processes and their representation as one-sided moving average processes.

Books for Study and Reference

1. Anderson, T. W. (2011). The Statistical Analysis of Time Series. John Wiley & Sons.
2. Bloomfield, P. (2004). Fourier analysis of Time Series - An introduction (Second Edition). John Wiley & Sons.
3. Box, G. E. P. and Jenkins, G.M. and Reinsel,G.C.(2013). Time Series Analysis - Forecasting and Control (Fourth Edition). Holden- Day, San Francisco.
4. Brockwell, P. J. and Davis, R. A. (2002). Introduction to Time Series and Forecasting.Taylor& Francis.
5. Chatfield, C. (1978). The Analysis of Time Series - Theory and Practice (Third Edition). Chapman and Hall, London.
6. Gupta, S. C. and Kapoor, V.K. (2007). Fundamentals of Applied Statistics (Fourth Edition). Sultan Chand & Sons Company, New Delhi.
7. Hannan, E. J. (1960). Time Series Analysis, Methuen, London.
8. Kendall, M. G. and Stuart, A. (1976). The advanced theory of Statistics, Vol.3, Charles Griffin, London.
9. Kendall, M. G. (1974). Time Series. Charles Griffin, London.
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11. Montgomery, D. C. and Johnson, L. A. (1977). Forecasting and Time Series analysis. McGraw Hill.
12. Priestley, M. B. (1981). Spectral analysis and Time Series. Griffin, London.

MODEL BLUEPRINT		
Subject Code		**18UPSTA4E11**
Title of the paper		**Time Series Analysis**
Unit Number	**Number of hours**	**Total Marks**
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER4.3.3: BAYESIAN METHODS

Semester	**IV**
Paper code	**18UPSTA4E12**
Paper title	**Bayesian Methods**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objectives

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

1. Describe Components of Bayesian Methods
2. Understand the Statistical decision theory – loss functions – 0-1.
3. Use exploratory tools : Point estimation – Bayes estimators
4. Bayesian and frequentist methods By accounting for time dependency by restriction
5. Bayesian hypothesis testing problem – prior odds, posterior odds, Bayes factor and their computations to various hypotheses testing problems – specification of Bayes tests

Course outcomes

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

- ✓ Understand Bayesian thinking;
- ✓ Use prior information and Bayes' rule in probability and statistical inference problems;
- ✓ Apply Bayesian inference methods to common parameters (binomial, Normal) and to relationships between variables; and
- ✓ Compare these with frequency methods.

Unit I: Decision Theory
Statistical decision theory – loss functions – 0-1, absolute error, squared error and LINEX loss functions – risk function – minimax solution – prior distribution – Bayes risk – Bayes solution to decision problems.

Unit II: :Prior Distribution
Subjective probability – its interpretation and evaluation - Subjective determination of prior distributions - Improper prior, noninformative prior, invariant prior, Jeffreysnon informative prior and natural conjugate prior – family of distributions admitting natural conjugate prior.

Unit III: Loss Functions
Point estimation – Bayes estimators under various loss functions – generalization to convex loss functions - Evaluation of the estimate in terms of posterior risk – comparison with frequentist methods.

Unit IV: Interval Estimation
Interval estimation – credible interval, highest posterior density region - Comparison of interpretation of the confidence co-efficient of an interval by Bayesian and frequentist methods – simple problems.

Unit V: Bayesian Hypotheses
Bayesian testing of statistical hypotheses – specification of the appropriate form of the prior distribution for Bayesian hypothesis testing problem – prior odds, posterior odds, Bayes factor and their computations to various hypotheses testing problems – specification of Bayes tests.

Books for Study and Reference

1. Bansal,A.K. (2007). Bayesian Parametric Inference.Narosa Publishing House, New Delhi.
2. Berger, J.O. (1985). Statistical Decision Theory and Bayesian Analysis (Second Edition). Springer Verlag, New York.
3. Bernardo, J.M. and Smith, A.F.M. (2000). Bayesian Theory. John Wiley & Sons, New York. (Reprint 2009).
4. Gelman,A., Carlin,J.B., Stern,H.B. and Rubin, D.B.(2013). Bayesian Data Analysis (Third Edition).CRC press.
5. Ghosh,J.K., Delampady, M. and Samanta, T. (2010). An Introduction to Bayesian Analysis: Theory and Methods. Springer Verlag, New York.
6. Lee, P.M. (2012). Bayesian Statistics – An Introduction (Fourth Edition). John Wiley & Sons, London.
7. Leonard, T. and J.S.J. Hsu. (1999). Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers. CambridgeUniversity Press, London.
8. Robert, C.P. (1994). The Bayesian Choice: A Decision-Theoretic Motivation (Second Edition). Springer Verlag, New York.
9. Robert,C.P. and Casella,G. (2004). Monte Carlo Statistical Methods (Second Edition). Springer Verlag, New York. (Reprint 2010).

MODEL BLUEPRINT		
Subject Code		**18UPSTA4E12**
Title of the paper		**Bayesian Methods**
Unit Number	Number of hours	Total Marks
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75

SEMESTER4.4: **STATISTICS PRACTICAL USING R - II**

Semester	**II**
Paper code	**18UPSTA4P04**
Paper title	**Statistics Practical using R - II**
Number of teaching hrs per week	**3**
Total number of teaching hrs per semester	**45**
Number of credits	**3**

Learning objective

Upon successful completion of this course, the students will be able to:
1. It provides a means of detecting error at inspection.
2. It provides a basis for attainable specifications.
3. Identify how changing values for a parameter affects the characteristics of the distribution.
4. Identify how changing values for a parameter affects the characteristics of the distribution.

Course outcomes

On successful completion of the course students will be able to:
- ✓ Demonstrate the ability to design, use, and interpret control charts for attributes.
- ✓ Explore data-sets to create testable hypotheses and identify appropriate statistical tests
- ✓ Perform appropriate statistical tests using R
- ✓ Use generating functions to determine distribution function and moments.
- ✓ Analyze alternative designs for experimentation and carry out output analysis for quality improvement projects.

Exercise under Standard Probability Distributions

1. Fitting of Binomial Distribution.
2. Fitting of Poisson Distribution.
3. Fitting of Normal Distribution.

Exercise under ANOVA and Design of Experiments

1. One – way and two – way analysis of variance
2. CRD, RBD and LSD

Exercise under statistical quality Control

1. Construction of control charts for mean, range and standard deviation of and X R charts.
2. Construction of control charts for attributes – p,c, np and u charts.

MODEL BLUEPRINT		
Subject Code		**18UPSTA4P04**
Title of the paper		**Statistics Practical using R – II**
Unit Number	Number of hours	Total Marks
1	9	15
2	9	15
3	9	15
4	9	15
5	9	15
Total	45	75
Maximum marks for the paper		75