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 2021 - 2022 onwards)

1. PERIYAR UNIVERSITY VISION AND MISSION

Vision

- Periyar University aims towards excellence in teaching, research, outreach, imparting new-age skills and preserving cultural identity for future generation.

Mission

- To offer need based, society driven, industrially relevant academic programmes with a view to make future ready citizens
- To provide a vibrant learning environment, fostering innovation and creativity inspired by cutting edge research
- To aspire as a national leader in developing educated contributors, career ready learners and global citizens
- To make a significant, consistent and sustainable contribution towards social, cultural and economic life
- To adopt Hassle free, distributed, committed and transparent governance

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
- Creating conducive and acceptable environment for innovation and critical 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.

Graduates Attributes

The purpose and existence of the University are created based on the golden verse/maxim inscribed in its logo “Arivaal Vilayum Ulagu” (-Wisdom Maketh the World), and its graduate attributes are consummated with this principle. The principal outcome of the University’s efforts and the core of its academic activities are the attributes of its graduates who are expected to reach their full potential whether as global citizens or as leaders in a competitive environment.

The Graduates of Periyar University are expected to have the following attributes in terms of knowledge, skills, and attitude:

- In-depth and extensive knowledge, comprehension, and requisite skills at internationally-recognized levels in their discipline(s) of specialization.
- Capacity to engage in independent, conceptual, and creative thinking.
- Ability to communicate effectively as an independent user for different purposes in their chosen domains of activity, and to formulate and convey views on subject matters.
- Competency to devise and implement strategies to fulfill the information required for complex tasks or scenarios across a range of contexts in the workplace.
- Introspect strengths and weaknesses as a leader/team member, and/or independently work on contemporary, social, and cultural issues and to make meaningful contributions to local, national, and global communities.
- Translate the acquired knowledge/skills effectively and productively with discipline-specific software to provide solutions to industry.
- Formulate strategies to identify, define, and solve problems and issues using established methods of enquiry to the global communities.
- Evaluate reflectively and think creatively within the context of a specific discipline.
- Articulate the potential for positive social change, equality of men and women, scientific spirit and contribution to the community/region of origin by dissemination/application of acquired knowledge and skills.
- Aptitude to engage in self-reflection and lifelong learning.

Quality Policy

"Only education, self-respect and rational qualities will uplift the downtrodden."
— Periyar E.V. Ramasamy

- Periyar University recognizes the need to embed quality assurance and continuous improvement mechanisms in all major activities in the provision of quality education to its stakeholders in line with the vision, mission, and the objectives of the University and is committed to provide organizational support for achieving quality at all levels to pursue global standards of excellence encompassing teaching, research, consultancy, extension, innovation, intellectual leadership, outreach, governance and administration through embedded processes of self-evaluation and continuous improvement in compliance with regulatory and statutory requirements.

- The policy applies to all staff, students, and other stakeholders. At the system level, all are involved and empowered to foster a culture of continuous improvement in all facets of the University. The outcomes are marked by sustained efforts toward innovation and improved delivery mechanism. There is encouragement for individual learning styles; promotion of multidisciplinary studies, and consistent teaching-learning evaluation. Research attainments are corroborated by peer reviewed publications, resulting in prototype/ knowledge products as a result of national and international collaborative research. Equity in opportunities is ensured for women, differently–abled persons, and minorities. Ample use of technology in place for all the activities with transparency and accountability at all levels adhering to the highest ethical standards. Stringent internal and external quality assessments realign and reposition the priorities perpetually.

2. DEPARTMENT VISION AND MISSION

Preamble

- Post graduate Statistics is a course focus on Statistics and its complete diversity exploring their relationship with the related disciplines. The Degree of Master of Science in Statistics aims to train the students in the development and applications of Statistical techniques for analysing data arising in the scientific investigation of problems in various disciplines. Curriculum includes Basics of core Statistics subjects. The students are also trained to handle real life problems through practical classes. As part of the course, the students are taught some programming languages and also trained in various statistical softwares such as SPSS-AMOS, R Programming and MS-Excel. The detailed syllabus for each paper is constructed to inculcate the graduate with outcome-based education pattern which provide space for Remember, Understand, Apply, Analyse, Evaluate and Create Knowledge (K1 –K6).

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 students and scholars continue to grow as professional statisticians, and providing public and professional service.

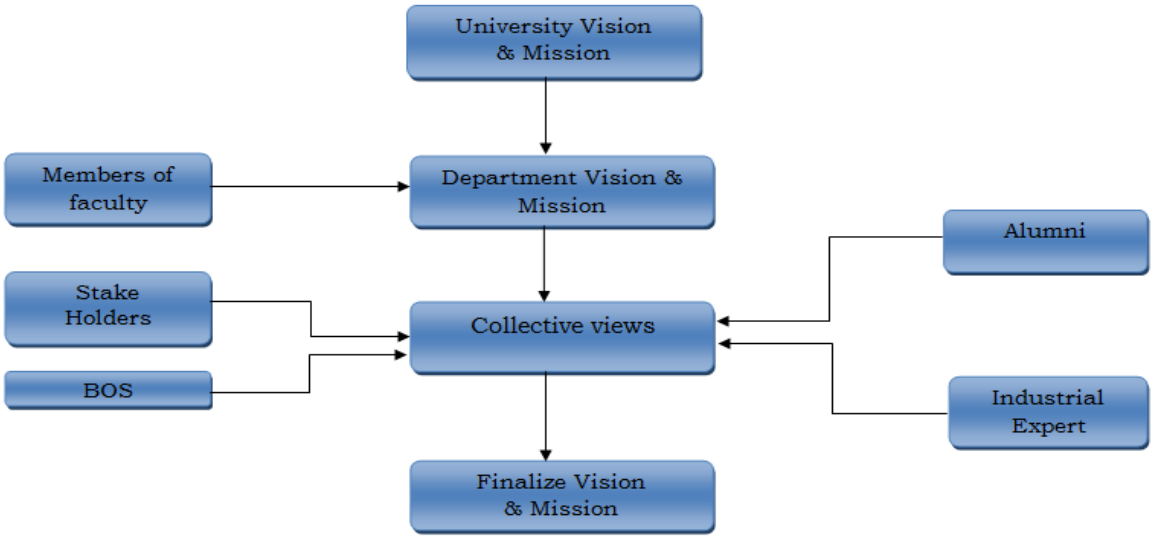
The Process for Defining Vision and Mission of the Department

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 is 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

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

Program outcomes (POs) 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.

Program Specific Outcomes (PSOs) 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

Program Educational Objectives (PEOs) On successful completion of the M. Sc., Statistics programme, the graduates will be able to:

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.

PEO6- Advancement

Nurture advancement in statistical theory and applications

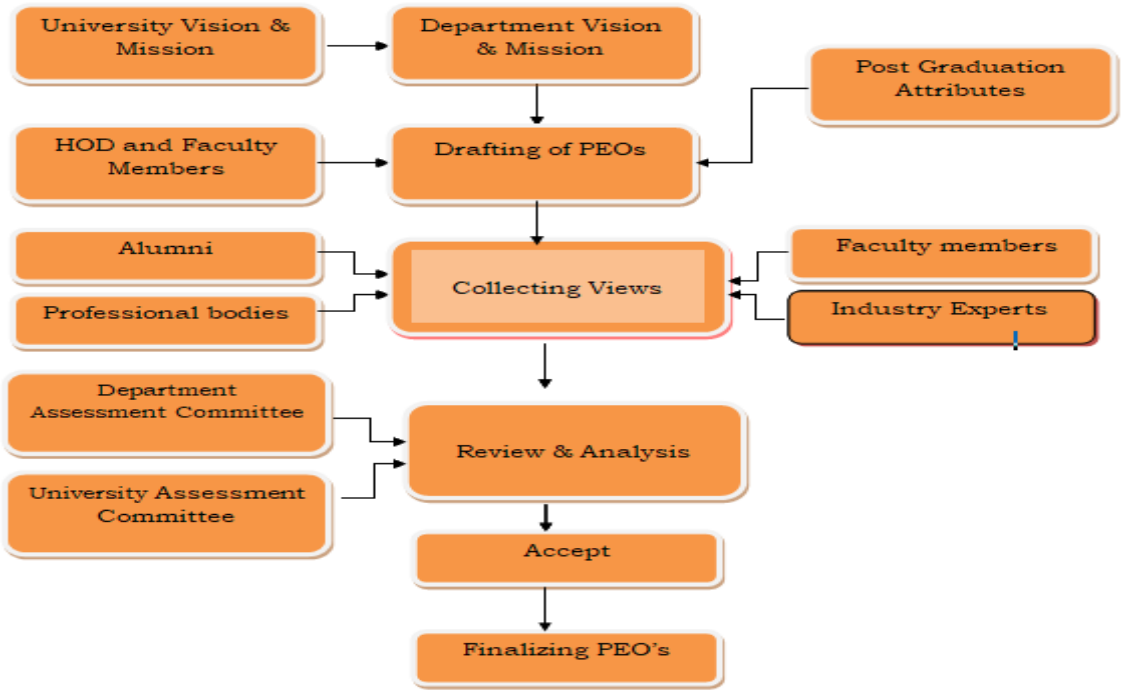
4.2 THE PROCESS FOR ESTABLISHING THE PEO's

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

On successful completion of the M. Sc., Statistics programme, the graduates will be able to:

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**	Utilize analytical skills for basic mathematical computation. Critically analyze statistical data and make interpretations. Gain effective skills to perform data analysis using statistical tools.
PO3	**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.

PO4	**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. Utilize software skills for statistical computation.
PO5	**Career Orientation**	Prepare to participate in competitive examinations at the state and national level. Acquire skills to meet the challenges in job placements.
PO6	**Application Based**	Identify potential areas of applications of statistical theory.
PO7	**Diversified Discipline**	Recognize the importance and value of statistical principles and approach for problem solving on a diversified discipline.
PO8	**Investigations Of Complex Problems**	Gain impetus to move for learning at higher level.
PO9	**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.
PO10	**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

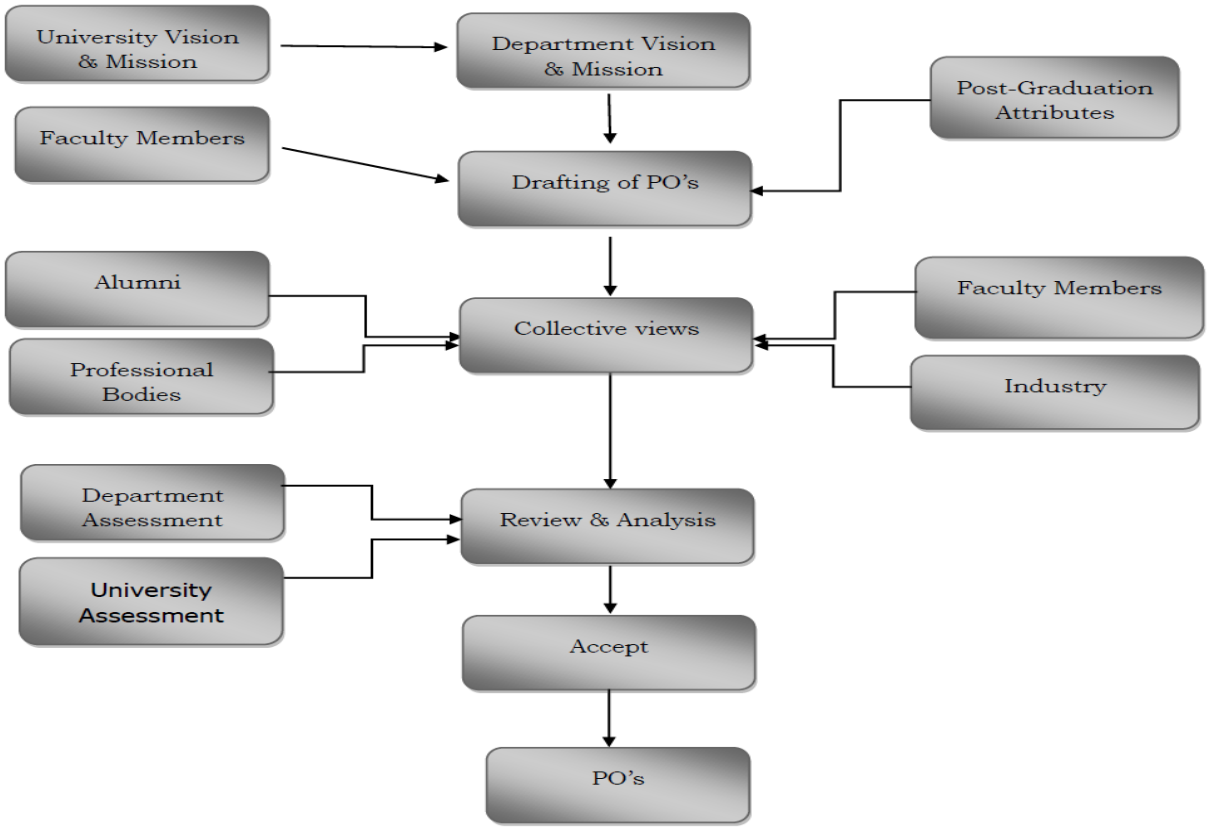
The POs are established through the following process steps:

The 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 PO's.
- **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.

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

FIG. 4.2.: ESTABLISHING THE PROGRAMME OUTCOMES



4.5 PROGRAM SPECIFIC OUTCOMES (PSOs):

The Post Graduates of the Statistics Department will Attain:

- 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.
- 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.
- 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.

On successful completion of M. Sc., Statistics Programme, the students will be expected to:

- **PSO1:** Comprehend the theoretical aspects of statistics
- **PSO2**: Recognize the application of statistics in diversified fields
- **PSO3**: Develop computer programs and codes for statistical computation
- **PSO4**: Utilize statistical software effectively for data analysis
- **PSO5**: Understand the conditions and limitations of statistical methods in application
- **PSO6:** Critically analyze statistical data and make interpretations

5. 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.
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.

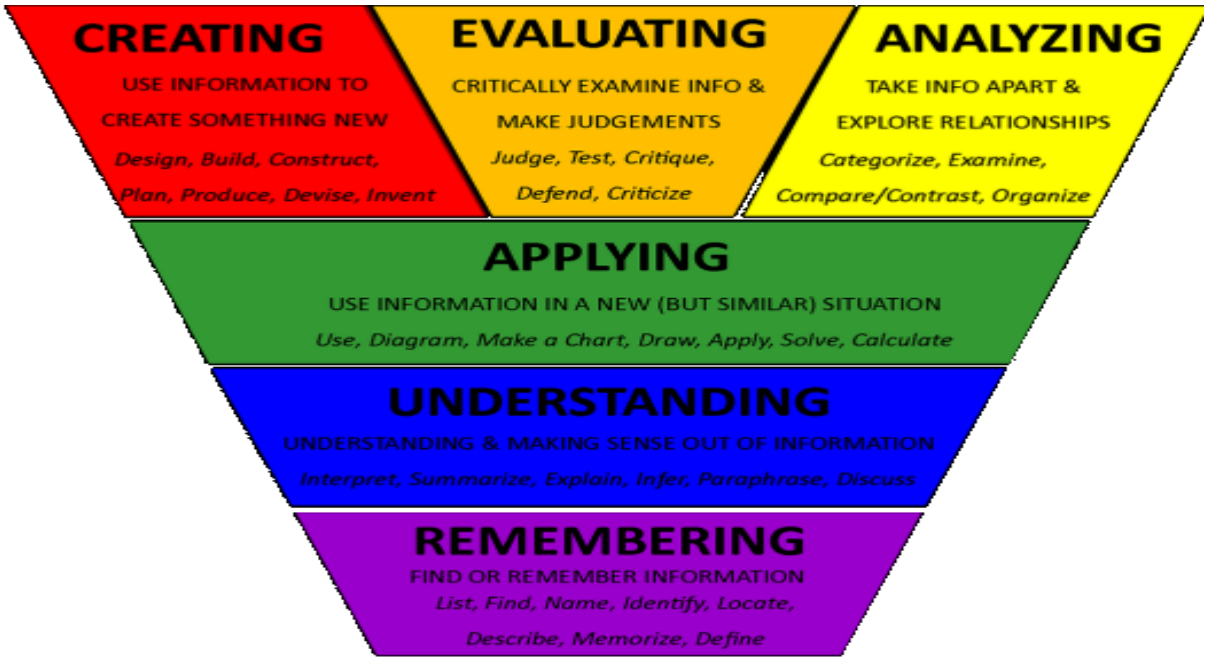


FIG. 5.1 PICTORIAL REPRESENTATION OF BLOOM'S TAXONOMY

6. COURSE OUTCOMES

6.1 COURSE OUTCOME STATEMENT

Statements indicating what a student can do after the successful completion of a course. Every Course led 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 CO's. 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 and Python.
- 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

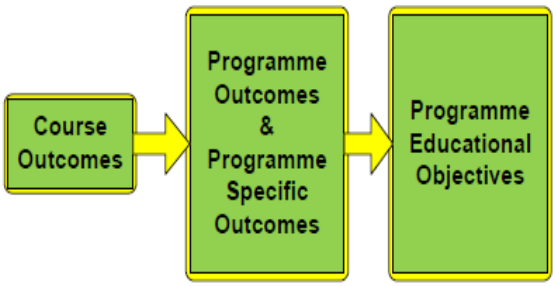
All the courses together must cover all the POs (and PSOs). For a course we map the COs to POs through the CO-PO matrix and to PSOs through the CO-PSO matrix as shown below. The various correlation levels are:

- "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 forms 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.

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	$\left.\begin{matrix} 02 \times 3 \text{Credits} \\ 02 \times 3 \text{Credits} \end{matrix}\right\} = 12$ 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.

Table 8.2 Course Structure and Scheme of Examination

Code	Title of the Subject	Examination				Credits
		Duration (Hrs/Week)	CIA Marks	External Marks	Total Marks	
SEMESTER I						
21UPSTA1C01	Real and Complex Analysis	4	25	75	100	4
21UPSTA1C02	Measure and Probability Theory	4	25	75	100	4
21UPSTA1C03	Distribution Theory	4	25	75	100	4
21UPSTA1C04	Sampling Theory	4	25	75	100	4
	Elective I	3	25	75	100	3
21UPSTA1P01	Statistics Practical I	4	40	60	100	3
SEMESTER II						
21UPSTA2C05	Linear Algebra	4	25	75	100	4
21UPSTA2C06	Estimation Theory	4	25	75	100	4
21UPSTA2C07	Multivariate Analysis	4	25	75	100	4
	Elective II	3	25	75	100	3
	Supportive Paper I	3	25	75	100	3
21UPSTA2P02	Statistics Practical II	4	40	60	100	3
06PHR01	Human Rights and Duties (No credit calculated)	**(Course Offered by Department of Sociology at University Level)**				2
SEMESTER III						
21UPSTA3C08	Hypothesis Testing	4	25	75	100	4
21UPSTA3C09	Statistical Quality Control	4	25	75	100	4
21UPSTA3C10	Demography and Vital Statistics	4	25	75	100	4
21UPSTA3C11	Econometrics and Time Series Analysis	4	25	75	100	4
	Elective III	3	25	75	100	3
	Supportive Paper II	3	25	75	100	3
21UPSTA3P03	Statistics Practical III (R programming)	4	40	60	100	3
SEMESTER IV						
21UPSTA4C12	Linear Models and Design of Experiments	4	25	75	100	4
21UPSTA4C13	Stochastic Processes	4	25	75	100	4
	Elective IV	3	25	75	100	3
21UPSTA4P04	Statistics Practical IV	4	40	60	100	3
21UPSTA4C14	Project/Dissertation with Viva-Voce	-	40	60	100	8
		Total	**675**	**1725**	**2400**	**92**

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.	21UPSTA1C01	Real and Complex Analysis	4
2.	21UPSTA1C02	Measure and Probability Theory	4
3.	21UPSTA1C03	Distribution Theory	4
4.	21UPSTA1C04	Sampling Theory	4
5.	21UPSTA2C05	Linear Algebra	4
6.	21UPSTA2C06	Estimation Theory	4
7.	21UPSTA2C07	Multivariate Analysis	4
8.	21UPSTA3C08	Hypothesis Testing	4
9.	21UPSTA3C09	Statistical Quality Control	4
10.	21UPSTA3C10	Demography and Vital Statistics	4
11.	21UPSTA3C11	Econometrics and Time Series Analysis	4
12.	21UPSTA4C12	Linear Models and Design of Experiments	4
13.	21UPSTA4C13	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.	21UPSTA1E01	Official Statistics	3
2.	21UPSTA1E02	Actuarial Statistics	3
3.	21UPSTA1E03	Data Mining	3
SEMESTER II / ELECTIVE II			
4.	21UPSTA2E04	Operations Research	3
5.	21UPSTA2E05	Simulation and Statistical Modelling	3
6.	21UPSTA2E06	Total Quality Management	3
SEMESTER III / ELECTIVE III			
7.	21UPSTA3E07	Categorical Data Analysis	3
8.	21UPSTA3E08	Statistical Methods for Epidemiology	3
9.	21UPSTA3E09	Biostatistics	3
SEMESTER IV / ELECTIVE IV			
10.	21UPSTA4E10	Applied Regression Analysis	3
11.	21UPSTA4E11	Statistical Computations Using Python (Practical Lab Based Course)	3
12.	21UPSTA4E12	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.	21UPSTA2S01	Basic Statistical Methods	3
2.	21UPSTA2S02	Statistics for Behavioural Sciences	3
3.	21UPSTA2S03	Probability and Statistics for Scientists	3
4.	21UPSTA2S04	Statistics for Researchers	3
Supportive Paper II / Semester III			
1.	21UPSTA3S01	Descriptive Statistics	3
2.	21UPSTA3S02	Computer Oriented Statistical Methods	3
3.	21UPSTA3S03	Statistics for Economics	3
4.	21UPSTA3S04	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 Examinations and Assignments.	PO1 to PO10	Two per Semester
Direct	Assignments	Three assignments are given for each course for continuous assessment. Average marks are considered.		PO1 to PO10	Continuous
Direct	Day to day evaluation	The day-to-day		PO1 to	Continuous

		evaluation is considered.	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.	PO10	
Direct	Internal Practical Examination	Three internal practical examination is conducted		PO1 to PO10	Three practical exams in every semester
Direct	External Practical	One external practical examination is conducted	One external practical exam is conducted	PO1 to PO10	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 PO10	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 PO10	IV Semester of PG Programme
Indirect	Alumni Survey	This survey gives the opinion of the student on the attainment of course outcomes.	At the end of the programme Alumni survey is collected from Alumni a considered for the PO attainment under Indirect assessment.	PO1 to PO10	At the end of each course

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 PO10	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 Subject

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 in-charge. 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 in-depth 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.

9.4.4 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.

9.4.5 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: Signature of the Guide

Place:
Counter signed: Signature of the Head of the Department

Model Table of Contents

9.5 Pattern of Question Paper for the End Semester Comprehensive Examination

The question paper shall consist of three sections. While there shall be

1. No choice in Part A,
2. Open choice in Part B and
3. 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 unit)
- 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

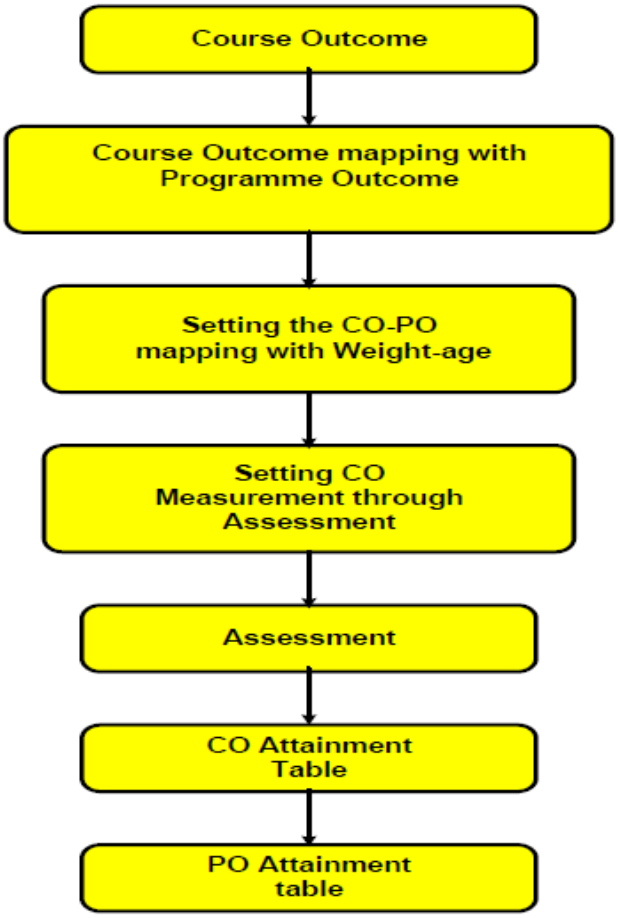
10. ATTAINMENT LEVELS

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 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="6">PO, PSO ASSESSMENT TOOLS</th></tr>
<tr><td rowspan="16">Direct (75% weightage)</td><td rowspan="16">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="2">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 rowspan="2">Once per course</td></tr>
<tr><td colspan="2">University Viva voice</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 course</td></tr>
<tr><td rowspan="3">Major Project</td><td colspan="2">Seminars</td><td>Twice per course</td></tr>
<tr><td colspan="2">External Viva voce</td><td>Once per</td></tr>
<tr><td colspan="2">Report</td><td>Once per</td></tr>
<tr><td rowspan="2">Indirect 20% Weightage</td><td rowspan="2">Surveys</td><td colspan="3">Graduate Exit Survey</td><td>At the end of the Program</td></tr>
<tr><td colspan="3">Alumni Survey</td><td>Once per year</td></tr>
</table>

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. 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.

(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.

11.4 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

An 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.

11.4.2 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.

SEMESTER 1

Semester 1.1. (21UPSTA1C01) - REAL AND COMPLEX ANALYSIS

Course Code	21UPSTA1C01	TITLE OF THE COURSE	L	T	P	C
Core 01		REAL AND COMPLEX ANALYSIS	4	-	-	4
Pre-requisite		Skills in Basic Mathematics and Complex Analysis	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. To understand the basic concept for topology of a real analysis valued function and theorems.
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 – sub sequence's, Upper, lower limits and Cauchy Sequences.
5. To understand certain theorems like the L' Hospital's Rule - Taylor's theorem.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related K's
1	The fundamental concepts of real and complex analysis and their role in modern mathematics and applied contexts.	K2, K3
2	Demonstrate accurate and efficient use of real analysis of numerical sequence and series.	K2, K4
3	Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from real analysis.	K1, K3
4	Apply problem-solving using real analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts.	K2, K5
5	The fundamental concepts of complex analysis and their role in modern mathematics and applied contexts.	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Basic Topology	12 hours
Basic Topology – Finite, Countable and Uncountable Sets - Definition – Theorem and Examples - Metric Spaces – Compact Sets – Bolzano Weierstrass theorem – Perfect Sets – The cantor set - Connected Sets - Theorem and examples.		
Unit:2	**Numerical Sequence and Series**	**12 hours**
Numerical Sequence and Series – Convergent Sequences – Subsequences and Cauchy Sequences – Upper and Lower Limits - Series - Series of nonnegative terms – The number e terms– Root and Ratio Tests – Power Series – Summation by Parts - Absolute Convergence – Addition and Multiplication of Series – Definition – Theorem and Examples.		
Unit:3	**Continuity and Limits of functions**	**12 hours**
Continuity – Limits of functions – Continuous functions - Continuity of Compactness and Connectedness – Discontinuity – Monotonic Functions – Infinite Limits and Limits at Infinity - Real functions – The derivation of real function - Mean Value Theorem – Continuity of derivatives – L' Hospital's Rule - Taylor's theorem – Differentiation of vector valued functions.		
Unit:4	**Riemann - Stieljtes (R-S) Integral Functions**	**12 hours**
Rieman - Stieljtes (R-S) integral – Properties – Integration and Differentiation – Integration of Vector – Valued functions – Rectifiable Curves - Uniform Convergence of Continuity and Integration and Differentiation – Stone – Weierstrass – Theorem and Examples.		
Unit:5	**Complex Analysis**	**12 hours**
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.		
	Total Lecture Hours	**60 hours**

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.

Reference Books

1. Arora, S, (1988), Real Analysis, Satya Prakashan Mandir, New Delhi.
2. Apostol, T. M, (1986), Mathematical Analysis, Second Edition, Addison Wesley, 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.
5. Richard R. Goldberg (1970) Methods of Real Analysis Oxford IBH publishing Co Pvt Ltd, New Delhi.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	S	L	L	S	S	L	L	S
CO2	S	M	M	S	S	M	M	S	S	M
CO3	L	S	S	L	L	S	S	L	L	S
CO4	M	L	L	M	M	L	L	M	M	L
CO5	M	S	S	L	M	M	S	L	L	L

*S- Strong; M-Medium; L-Low

Semester 1.2. (21UPSTA1C02) - MEASURE AND PROBABILITY THEORY

Course Code	21UPSTA1C02	TITLE OF THE COURSE	L	T	P	C
Core 02		MEASURE AND PROBABILITY THEORY	4	-	-	4
Pre- requisite		Basics in Set theory, Probability, Algebra	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Aid the students to conquer the basic knowledge of measure theory needed to understand probability theory.
2. Expertise in mastering the probability theory and their applications.
3. Apprehend the probability concepts (random variables, expectation, and limits) within the frame work of measure theory

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related K's
1.	Understand the concepts of measure and comprehend some basic knowledge of sets, function and limits	K1, K4
2.	Summarize random variables, distribution functions, identifying the applications of inequalities in probability theory	K2, K3
3.	Examine the modes of convergence and organizing the concepts of convergence in distribution functions	K2, K4
4.	Integrate the ideas of characteristic functions and its properties, reviewing the conception independence of random variables in probability theory.	K3, k4
5.	Explore the applications of law of large numbers and central limit theorem.	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Set theory and Measure theory	12 Hours

Algebra of sets -finite and infinite sets, ring - set function- field - σ-field - minimal σ-field - Borelfield - sequences of sets - limit inferior and limit superior of sequences of sets - Measure - Measurable space - measure space – properties of measure - Measurable functions - Lebesgue measure and Lebesgue- Stieltjes measure.		
Unit 2	**Probability and inequalities**	**12 Hours**
Random variable – discrete and continuous random variables -Probability space - probability measure – properties of probability measure. Distribution function – Properties – Decomposition of distribution function - expectation - Conditional probability and conditional expectation – Inequalities (Basic, Chebyshev's, Markov's, Holder's, Jensen's and Minkowski's inequalities) – product space		
Unit 3	**Modes of Convergence**	**12 Hours**
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 Bray lemma (statement only)		
Unit 4	**Characteristic Function**	**12 Hours**
Characteristic Function: Definition and Properties - Uniqueness Theorem - Inversion Formula – 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 5	**Law of large numbers**	**12 Hours**
Law of large numbers: Weak and strong law of large numbers - Bernoulli'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).		
	Total Lecture hours	**60 hours**

Text Books:

1. Bhat B. R, (2014), Modern Probability Theory (Fourth Edition), New Age International, New Delhi (Reprint 2015).
2. Basu A. K (2012). Measure theory and Probability, Prentice Hall India Learning Private Limited, New Delhi

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	L	M	S	S	L	M
CO2	M	S	L	M	M	S	M	L	S	L
CO3	M	S	S	L	L	M	L	M	L	S
CO4	S	M	L	M	L	S	L	L	M	L
CO5	S	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 1.3. (21UPSTA1C03) - DISTRIBUTION THEORY

Course Code	21UPSTA1C03	TITLE OF THE COURSE	L	T	P	C
Core 03		DISTRIBUTION THEORY	4	-	-	4
Pre- requisite		Basic knowledge in Probability theory	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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. The aim of this course is to provide a thorough theoretical grounding in different type of distributions, non-central distributions, etc.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Calculate moments and generating functions	K5
2	Determine and interpret independence and conditional distributions	K1
3	Construct z, chi-squared, t and F tests and the corresponding confidence intervals from sample means and sample variances	K4
4	Apply chi-squared tests for contingency tables and goodness of fit	K3
5	Use generating functions to determine distribution function and moments	K2, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Basic Distribution theory	12 Hours

Basic distribution theory – Joint, marginal and conditional probability mass functions and probability density functions. Methods of finding distributions: Cumulative Distribution Function - Jacobian transformation. Standard distributions for Binomial, Poisson, multinomial and Normal probability distributions.

Unit 2	**Bivariate and Truncated Distributions**	**12 Hours**

Bivariate binomial, Bivariate poisson, Bivariate normal distributions - Concept of truncated distribution (Binomial & Poisson) - Compound distribution (Poisson) - Mixture distribution and their properties.

Unit 3	**Types of Distributions**	**12 Hours**

Geometric, Hyper Geometric, Negative Binomial, Power Series and logarithmic distributions properties and relationships.

Unit 4	**Distributions and its Properties**	**12 Hours**

Exponential, Laplace, Logistic, Lognormal, Cauchy, Gamma, Bet distribution – sampling distributions – Central – t, Central – F, Central Chi – Square distributions – Properties and relationships.

Unit 5	**Order Statistics and their properties**	**12 Hours**

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

	Total lecture hours	**60 hours**

Text Books:

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

Reference Books:

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 Allied Publishers, New Delhi.
7. David H. A. and Nagaraja H.N. (2003): Order Statistics, 3/e, John Wiley & Sons.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	L	M	S	M	M	M	S
CO2	M	L	M	S	L	M	S	L	L	M
CO3	M	L	S	M	M	S	L	S	M	L
CO4	M	M	L	M	S	M	L	M	M	S
CO5	S	M	S	S	M	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 1.4. (21UPSTA1C04) -SAMPLING THEORY

Course Code	21UPSTA1C04	TITLE OF THE COURSE	L	T	P	C
Core 04		SAMPLING THEORY	4	-	-	4
Pre- requisite		Basics of descriptive statistics and sampling	Syllabus Version		2021-2022	

Course Objective

The main objectives of this course are 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.

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Understand the principles underlying sampling as a means of making inferences about a population	K1
2	Understand the difference between randomization theory and model-based analysis	K2, K4
3	Understand the concepts of bias and sampling variability and strategies for reducing these.	K3
4	Be able to analyze data from multi-stage surveys	K4
5	Have an appreciation of the practical issues arising in sampling studies.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Notions of Sample Survey	12 Hours
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 2	**Simple Random Sampling**	**12 Hours**
Simple Random Sampling Without Replacement (SRSWOR), Simple Random Sampling With Replacement (SRSWR) – Procedure for Selection – 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 – interpreting sub-samples.		
Unit 3	**Stratified Random Sampling**	**12 Hours**
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 4	**Systematic and Cluster Sampling**	**12 Hours**
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 5	**Varying Probability Sampling, Ratio and Regression Estimators**	**12 Hours**
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.		
	Total Lecture hours	**60 hours**

Text Books:

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).
3. Desraj, Promod Chandhok (1998) Sample Survey theory, Narosa Publishing House Pvt. Ltd, New Delhi.
4. Parimal Mukhopadhyay (1998) Theory and Methods of Survey Sampling, Prentice Hall of India Pvt. Ltd.
5. Archana Bansal (2017) Survey Sampling, Narosa Publishing House Pvt. Ltd, New Delhi.

Reference Books:

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.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	S	M	L	S	M	S	M	S	S
CO3	S	S	M	L	S	M	S	M	S	S
CO4	S	S	M	L	S	M	S	M	S	S
CO5	S	S	M	L	S	M	S	M	S	S

*S – Strong, M- Medium, L- Low

Semester 1.5. Elective-I

Semester 1.5.1. (21UPSTA1E01) - OFFICIAL STATISTICS

Course Code	21UPSTA1E01	TITLE OF THE COURSE	L	T	P	C
Elective-01		OFFICIAL STATISTICS	3	-	-	3
Pre- requisite		Basic ideas of health, social and economic sectors	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Understand the functioning of government and policies.
2. Promote human resource development in the official statistics and encourage research and development in theoretical and applied statistics.
3. Execute the data handling tasks in various government records.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understand the fundamentals and students will become familiar with institutional, legal and organizational bases, and principles of functioning in official statistics.	K1
2	Evaluate the methods for data collection, analysis and interpretation of health, social and economic.	K5
3	Use appropriate methods for presenting and preparing commentaries on official statistics.	K2, K3
4	Learn the methodological bases of measurement in official statistics and execute the tasks in agricultural and economic statistics	K4
5	Overcome the limitations that arises from measurement and processes of statistical production	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	**Statistical System in India**	**9 Hours**
Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO). Organization of large-scale sample surveys. General and special data dissemination systems.		
Unit 2	**Official Statistics**	**9 Hours**
Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.		
Unit 3	**Agricultural and Social Statistics**	**9 Hours**
System of Collection of Agricultural Statistics - Crop forecasting and estimation - Productivity, fragmentation of holdings - Support prices - Buffer stocks - Impact of irrigation projects. Statistics related to industries, foreign trade - Balance of payment - Inflation - Social statistics		
Unit 4	**Index Numbers**	**9 Hours**
Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses.		
Unit 5	**National Income**	**9 Hours**
National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India. Measurement of income inequality: Gini's coefficient, Lorenz curves, Application of Pareto and Lognormal as income distribution		
	Total lecture hours	**45 hours**

Text Books:

1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
3. C.S.O. (1995). Statistical System in India.
4. C. S. O. (1999). Guide to Official Statistics.
5. Mukhopadhyay, P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
6. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi
7. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.

Reference Books:

1. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
2. Panse, V. G. (1964). Estimation of Crop Yields (FAO), Food and Agriculture Organization of the United Nations.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	L	M	S	S	L	M
CO2	M	S	L	M	M	S	M	L	S	L
CO3	M	S	S	L	L	M	L	M	L	S
CO4	S	M	L	M	L	S	L	L	M	L
CO5	S	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 1.5.2. (21UPSTA1E02) - ACTUARIAL STATISTICS

Course Code	21UPSTA1E02	TITLE OF THE COURSE	L	T	P	C
Elective-02		ACTUARIAL STATISTICS	3	-	-	3
Pre- requisite		Basic knowledge in Insurance calculation	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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 and assess the suitability of actuarial, financial and economic models in solving actuarial problems.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Fit simple linear regression models and interpret model parameters.	K2, K3
2	Demonstrate the necessary analytical skills for interpreting and analysing actuarial and statistical information.	K4
3	Demonstrate well developed insight into the international financial markets.	K4
4	Demonstrate the skills necessary to critically engage with and evaluate actuarial and statistical problems.	K1-K4
5	Assess and refine simple and multiple linear regression models based on diagnostic measures, identifying outlying and influential data points.	K1-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate; **K6** – Create

Unit 1	Basic deterministic model	9 Hours
The life table: Basic definitions, probabilities, construction of life tables, life expectancy, Life annuities: Introduction, calculating annuity premium, interest and survivorship discount function, guaranteed payments, deferred annuities.		
Unit 2	**Life insurance**	**9 Hours**
Introduction, calculation of life insurance premiums, types of life insurance, combined benefits, insurances viewed as annuities, Insurance and annuity reserves: The general pattern reserves, recursion, detailed analysis of an insurance.		
Unit 3	**Policy Values**	**9 Hours**
Fractional durations: Life annuities paid monthly, immediate annuities, fractional period premium and reserves, reserves at fractional durations, Continuous payments: Continuous annuities, force of discount, force of mortality, Insurance payable at the moment of death, premiums and reserves		
Unit 4	**Multiple life contracts**	**9 Hours**
Joint life status, joint annuities and insurances, last survivor annuities and insurances, moment of death insurances. The general two life annuity and insurance contracts, contingent insurances		
Unit 5	**Multiple decrement theory**	**9 Hours**
Basic model, insurances, Determination of the models from the forces of decrement. Stochastic approach to insurance and annuities; Stochastic approach to insurance and annuity benefits, deferred contracts, Stochastic approach to reserves and premiums, variance formula		
	Total lecture hours	**45 hours**

Text Books:

1. Promislow, S.D(2006): Fundamentals of Actuarial Mathematics, John Willey, Chapters 2- 11 &14.
2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil J. Nesbitt (1997): Actuarial Mathematics, The Society of Actuaries
3. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press.
4. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press

Reference Books:

1. Neill, A. (1977): Life contingencies, Heinemann, London.
2. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
3. Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.
4. Jordan, C.W. Jr. (1967): Life Contingencies, Second edition, Chicago Society of Actuaries.
5. Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	L	M	S	S	L	M
CO2	M	S	L	M	M	S	M	L	S	L
CO3	M	S	S	L	L	M	L	M	L	S
CO4	S	M	L	M	L	S	L	L	M	L
CO5	S	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 1.5.3. (21UPSTA1E03) - DATA MINING

Course Code	21UPSTA1E03	Title of the Course	L	T	P	C
Elective-03		DATA MINING	4	1	-	4
Pre-requisite		Data, Data Structure and Data Source	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Demonstrate an understanding of the importance of data mining and the principles of business intelligence.	K1
2	Organize and prepare the data needed for data mining using pre-processing techniques.	K2
3	Perform exploratory analysis of the data to be used for mining.	K3
4	Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.	K4, K5
5	Define and apply metrics to measure the performance of various data mining algorithms.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction	9 hours
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 2	**Data Mining Primitives**	**9 hours**
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 3	**Models based on Summarization**	**9 hours**
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 4	**Clustering Algorithms**	**9 hours**
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 5	**Web Mining**	**9 hours**
Introduction - Webdata - Web Knowledge Mining Taxonomy - Web Content mining - Web Usage Mining Research - Ontology based web mining Research - Web mining Applications.		
	Total lecture hours	**45 hours**

Books for Study

1	Adriaans, P., and Zantinge, D. (1996). Data Mining, First Edition, Addison Wesley Professional, London
2	Agneswaran, V. S. (2014). Big Data Analytics Beyond Hadoop, First Edition, Pearson FT Press.
3	Gupta, G. K. (2014). Introduction to Data Mining with Case Studies, Third Edition, PHI Learning Private Limited, New Delhi.

Reference Books

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.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	S	S	S	S	S
CO2	S	S	L	S	S	S	S	S	S	S
CO3	S	S	L	S	M	S	S	S	M	M
CO4	S	S	L	S	M	M	S	S	M	M
CO5	S	S	L	S	M	S	S	S	M	M

*S-Strong; M-Medium; L-Low

Semester 1.6. (21UPSTA1P01) - STATISTICS PRACTICAL I

Course Code	21UPSTA2P01	TITLE OF THE COURSE	L	T	P	C
Core Practical I		STATISTICS PRACTICAL I	4	-	-	3
Pre- requisite		Basic Probability and fundamentals of distribution and sampling theory	Syllabus Version		2021-2022	

Course Objective

The main objectives of the course are to:

1. Identify the relation between the desired sample, the obtained sample, the sampling frame, and sample quality.
2. Fostering understanding through real-world statistical applications.
3. The concept of distribution theory and fitting of distribution may be evaluated.

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Identify possible values for each random variable and verify how the parameter affects the characteristics of the distribution.	K1 - K4
2	Students will apply concepts of various probability distributions to find probabilities and interpreting the basic distribution	K2 - K4
3	Demonstrating simple random sampling and stratified random sampling	K2 - K4
4	Understanding the concepts of systematic sampling and regression estimator	K1 - K3
5	Designing double sampling methods and performing cluster sampling	K1 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyse; **K5** - Evaluate; **K6** – Create

Distribution Theory

Exercise under Distribution Theory: 1. Fitting of Binomial distribution. 2. Fitting of Poisson distribution. 3. Fitting of Normal distribution by area and ordinate methods.	**15 Hours**

Sampling Theory

Exercise under Sampling Theory: 1.Estimation of population total, mean and variance under simple random sampling. 2.Stratified sampling SRS, PPSWR, PPSWOR - Ratio Estimator (including ratio estimator for stratified sampling – separate and combined) 3.Regression Estimator (including regression estimator for stratified sampling – separate and combined) 4.Estimation of population total, mean and variance under systematic sampling, Linear and circular systematic sampling 5.Estimation of population total, mean and variance under single - stage and two - stage cluster Sampling, Cluster Sampling (Cluster of Equal sizes) 6.Ratio, Regression and Difference estimation estimators. 7.Estimation of population total, mean and variance under double sampling methods.	**45 Hours**

Text Books:

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

Reference Books:

1. Karian, Z.A., and Dudewicz, E.J. (2011). Handbook of Fitting Statistical Distributions with R, Chapman and Hall.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	S	S	S	S	S	S	S
CO2	S	S	L	S	S	S	S	S	S	S
CO3	S	S	L	S	M	S	S	S	M	M
CO4	S	S	L	S	M	M	S	S	M	M
CO5	S	S	L	S	M	S	S	S	M	M

*S – Strong, M- Medium, L- Low

SEMESTER 2

Semester 2.1. (21UPSTA2C05) - LINEAR ALGEBRA

Course Code	21UPSTA2C05	TITLE OF THE COURSE	L	T	P	C
Core 05		LINEAR ALGEBRA	4	-	-	4
Pre- requisite		Fundamentals of Set theory, Modern Algebra, Matrix	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:
1. Impart the understanding of the basic concepts of linear algebra
2. Enhance the ability of solving the problems in linear algebra concepts such as linear transformation etc.,
3. Understand the concepts of characteristics roots and vectors
4. Interpreting the concepts which are essential for learning other courses

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understand the concepts of matrix and determinants comprehend some basic knowledge of elementary transformation of matrices	K1, K4
2	Summarize vector space, vector subspace, span, basis dimensions and evaluating the applications of nullity of matrices.	K2, K3
3	Examine the properties of inner product and organizing the concepts of orthogonality in inner product space.	K2, K4
4	Integrate the ideas of characteristic roots and characteristic vectors, its properties, reviewing the conception of criteria for diagonalizability.	K3, K5
5	Explore the applications of quadratic forms and generalized inverse	K2, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	**Matrix and Determinants**	**12 Hours**
Matrix and determinants - properties - matrix operation - system of linear equation- elementary operation - row reduced echelon form of matrix- rank of a matrix and the solution set of a linear system, row space, column space, null space.		
Unit 2	**Vector space**	**12 Hours**
Axiomatic definition of vector space - vector subspace - linear span - finite dimensional vector space, basis and dimension – Linear dependence and independence - Linear transformations of vectors – nullity of matrix.		
Unit 3	**Inner Product space**	**12 Hours**
Inner product for real and complex spaces – Properties of inner product, inner product space - Orthogonality of vectors and matrices – Orthonormalization process with exercises		
Unit 4	**Characteristic roots and characteristic vectors**	**12 Hours**
Characteristic roots and characteristic vectors - Cayley-Hamilton theorem. Minimum polynomial, similar matrices, algebraic and geometric multiplicities of a characteristic root - diagonalizable matrices- criteria for diagonalizability		
Unit 5	**Quadratic forms and G-inverse**	**12 Hours**
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 - Generalized inverse of matrix - Properties		
	Total lecture hours	**60 hours**

Text Books:

1. Vasishta, A. R. (2019). Matrices. Krishna Prakashan Mandir, New Delhi.
2. Graybill, F.A. (1983). Matrices and Applications in Statistics, Wadsworth Publishing Company, Belmont, California, USA.
3. Shanti Narayanan (2018) "A test book of matrices" S Chand & Co, New Delhi.
4. K. B. Datta (2000) Matrix and Linear Algebra, Printice – Hall of India Pvt.Ltd.

Books for References

1. Hohn, F.E. (2013). Elementary Matrix Algebra, Amerind Publishing Co. Pvt. Ltd., New Delhi.
2. Rao, C.R. (2009). Linear Statistical Inference and Its Applications, Wiley Eastern, New Delhi.
3. Searle, S.R. (2007). Matrix Algebra Useful for Statistics, John Wiley, New York.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	M	L	M	S	S	L	M
CO2	M	S	L	M	M	S	M	L	S	L
CO3	M	S	S	L	L	M	L	M	L	S
CO4	S	M	L	M	L	S	L	L	M	L
CO5	S	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 2.2. (21UPSTA2C06) - ESTIMATION THEORY

Course Code	21UPSTA2C06	TITLE OF THE COURSE	L	T	P	C
Core 06		ESTIMATION THEORY	4	1	-	4
Pre-requisite		Knowledge in Probability Theory and Probability Distributions	Syllabus Version		2021-22	

Course Objectives

The main objectives of this course are to:

1. Review the basic concepts of parametric estimation
2. Study the different methods of point and interval estimation
3. Study properties and methods of statistical estimation theory
4. Study various method of construct confidence intervals

Expected Course Outcomes

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

1	Understand the concepts and importance of properties of estimators	K3
2	Obtain the optimal estimator for a given parametric distribution function	K6
3	Study the different methods of point estimation	K3
4	Observe consistent and asymptotic behavior of estimators	K5
5	Construct confidence intervals for population parameters in large and small samples	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Criteria of Point Estimation	12 hours
Point Estimation – Minimum mean square error criterion – Unbiased Estimators – Sufficient Statistics – Fisher's information measure – Neyman Factorization theorem, Complete Statistics, Minimal Sufficiency – Exponential family of distributions.		
Unit:2	**Optimal Estimator**	**12 hours**
Minimum Variance Unbiased Estimator – Single Parameter, Uniformly Minimum Variance Unbiased Estimator – Rao Blackwell's theorem – Lehmann-Scheffe's theorem – Lower Bounds for Variance of Unbiased Estimator (Cramer – Rao Inequality) – Bhattacharya's Inequality – Chapman – Robbin's Inequality – Fisher's Information Matrix – Simultaneous in parameters of Univariate Normal Distribution.		
Unit:3	**Methods of Estimation**	**12 hours**
Methods of estimation – method of moments – method of maximum likelihood estimators – Properties - Method of minimum chi square - Method of modified minimum chi- square estimators – Method of Least Squares.		
Unit:4	**Consistent Estimators and Asymptotic Properties**	**12 hours**
Consistency and CAN Estimators, BAN Estimators - Consistent estimators – Weak Consistency – Strong Consistency – Mean Square Consistency- Fisher Consistency – Asymptotic properties of maximum likelihood estimators – Pitman families of distributions.		
Unit:5	**Interval Estimation**	**12 hours**
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 for mean, variance of a normal population, difference between mean and ratio of two normal populations – 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	Rohatgi, V. K and Saleh, A.K.Md.E, (2011), An Introduction to Probability and Statistics Second Edition, John Wiley & Sons, New York.

Reference Books

1. Rajagopalan M and Dhanavanthan P, (2012), Statistical Inference, PHI Learning Pvt. Ltd., New Delhi.
2. Lehman, E. L., and Cassella, G. (1998). Theory of Point Estimation, Second Edition, Springer, NY.
3. Mood A.M, Graybill F.A and Boes D.C, (1974), Introduction to Theory of Statistics, Third Edition, McGraw-Hill International Edition.
4. Manoj Kumar Srivastava, Abdul Hamid Khan and Namita Srivastava (2014). Statistical Inference – Theory of Estimation, piti Learning Pvt. Ltd, Delhi.
5. Santhakumaran A (2004) Probability Models and their Parametric Estimation, K.P.Jam Publication, Chennai.
6. Zack S (1971) "The theory of Statistical Inference", John Wiley, Newyork.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	M	S
CO2	S	M	M	L	S	M	S	M	M	S
CO3	S	M	M	L	S	M	S	M	M	S
CO4	S	S	M	M	S	M	S	M	M	S

*S – Strong, M- Medium, L- Low

Semester 2.3. (21UPSTA2C07) - MULTIVARIATE ANALYSIS

Course Code	21UPSTA2C07	TITLE OF THE COURSE	L	T	P	C
Core 07		MULTIVARIATE ANALYSIS	4	-	-	4
Pre- requisite		Knowledge in Multivariate Data Analysis Techniques	Syllabus Version		2021-2022	

Course Objective

The main objectives of this course are 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.
4. Introduce the language of multivariate data analysis
5. Understand the characteristics of multivariate quantitative research, including strengths and weaknesses
6. Understand the principles and characteristics of the multivariate data analysis techniques

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Distinguish between dependence and interdependence methods in multivariate data analysis.	K1
2	Identify the most appropriate statistical techniques for a multivariate dataset	K2-K5
3	Carry out and apply commonly used multivariate data analysis techniques, and interpret results	K3
4	Use statistical software packages for the analysis of multivariate data	K4
5	Will be able to use multivariate techniques appropriately, undertake multivariate hypothesis tests, and draw appropriate conclusions.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction of Multivariate Normal Distribution	12 Hours

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 2	**Random Sampling**	**12 Hours**

Estimation of the Mean vector and the covariance matrix in 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 3	**Statistic and Its Distribution**	**12 Hours**

Generalized T^2 - Introduction, derivation of the generalized T^2-statistic and its distribution - Hotelling's T^2 statistic, properties, applications and its distribution- Two sample problems with unequal covariance matrices likelihood ratio criterion and its applications - Mahalanobis D^2 statistic and its distribution - Relationship between T^2 and D^2 statistics – Behrens – Fisher problem.

Unit 4	**Factor Analysis and Canonical Correlations**	**12 Hours**

Wishart distribution - Characteristic function and properties - Sampling distribution of sample covariance matrix - 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 5	**Principal Component Analysis**	**12 Hours**

Problem of Classification – Two Populations and k – Populations – Principal Components and their determination – Canonical Correlations and Canonical Variables – Estimation of Canonical Correlations and Variables, Factor Analysis – Estimation of Factor Loading – Cluster Analysis.

	Total lecture hours	**60 hours**

Text Books:

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.
3. Bryan F.J. Manly (2004) "Multivariate Statistical Methods", A Primer, Third Edition.
4. Johnson, R.A. and D.W. Wichern. (2013). Applied Multivariate Statistical Analysis (Sixth Edition), Pearson New International Edition.

Reference Books:

1. W.R. Dillon and M. Goldstein (1984) "Multivariate Analysis Methods and Applications", Wiley, Newyork.
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. Alvin C. Rencher and William F. Christensen (2012). Methods of Multivariate Analysis.

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	S	L	M	M	S	M	S	M
CO2	L	M	M	S	M	S	M	S	S	L
CO3	M	S	M	S	S	L	M	S	M	M
CO4	S	S	M	S	M	S	S	L	M	S
CO5	S	S	S	M	S	M	S	S	L	M

*S – Strong, M- Medium, L - Low

Semester 2.4. Elective II

Semester 2.4.1. (21UPSTA2E04) - OPERATIONS RESEARCH

Course Code	21UPSTA2E04	TITLE OF THE COURSE	L	T	P	C
Elective - 04		OPERATIONS RESEARCH	3	-	-	3
Pre- requisite		Basic knowledge in operations research	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Understand the importance and concepts of optimization
2. Obtain the optimal solution for both linear and non-linear problem
3. Form and address solution to any real time optimization problem
4. Explain the Applications of Operations Research
5. Describe the Limitations of Operation Research
6. Understand the OR specialist and Manager relationship

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Identify and develop operational research models from the verbal description of the real system.	K1-K2
2	Understand the mathematical tools that are needed to solve optimization problems.	K2
3	Use mathematical software to solve the proposed models.	K4
4	Develop a report that describes the model and the solving techniques.	K5
5	Analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.	K3-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	**Operations Research**	**9 Hours**
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 – Primal and dual LPP and duality theorem; Methods using artificial variables - Dual Simplex Method – Simple Problems.		
Unit 2	**Transportation Problems**	**9 Hours**
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 3	**Queueing Theory**	**9 Hours**
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). Model I II: (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 4	**Theory of Inventory**	**9 Hours**
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 5	**Replacement Problems**	**9 Hours**
Replacement Problems: Replacement of deteriorating items – Complete replacement of items – Individual and Group Replacement Policies. Network analysis by CPM/PERT: Basic Concept - Constraints in Network – Meaning and Description – Determination of Critical Path.		
	Total lecture hours	**45 hours**

Text Books:

1. Taha, H.A (2011). Operations Research: An Introduction, Ninth Edition, Prentice Hall Publishing Company.
2. Gupta, P.K., and Man Mohan. (1979). Operations Research: Linear Programming and Theory of Games, Third Edition, Sultan Chand and Sons, New Delhi.
3. Kanti Swarup, P.K. Gupta and Manmohan (2007) "Operation Research", Sultan Chand Son's, New Delhi.

Reference Books:

1.Gass, S. I. (1985). Linear Programming, Methods and Applications. Courier Dover Publications. (Reprint 2003)
2. Hadley, G (1963): Linear Programming. Addison Wesley Publishing Company.
3. Hillier, F.S., and Lieberman, G.J. (2005). Introduction to Operations Research, Ninth Edition, McGraw – Hill Publishing Company.
4. Sharma, J.K. (2013). Operations Research: Problems and Solutions, Fifth Edition, Macmillan India Limited.
5. Sharma, S. D. (2010). Operations Research, Kedar Nath, Ram Nath and Co, Meerut.
6. Gass Saul. I (1975) "Linear Programming Methods and Applications", 4th Edition McGraw Hill, New Delhi.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	M	M	L	S	L	M	S
CO2	M	S	S	L	M	M	S	M	S	M
CO3	L	M	M	S	M	S	M	S	S	L
CO4	M	S	L	M	L	M	M	S	L	L
CO5	S	S	L	M	M	L	L	S	S	L

*S – Strong, M- Medium, L - Low

Semester 2.4.2. (21UPSTA2E05) - SIMULATION AND STATISTICAL MODELLING

Course Code	21UPSTA2E05	TITLE OF THE COURSE	L	T	P	C
Elective - 05		SIMULATION AND STATISTICAL MODELING	3	-	-	3
Pre- requisite		Emphasizes the Development of Modeling	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Define the basics of simulation modeling and replicating the practical situations in organizations
2. Generate random numbers and random variates using different techniques.
3. Analysis of Simulation models using input analyzer, and output analyzer
4. Explain Verification and Validation of simulation model.
5. The ability to apply the appropriate analytical technique to a wide variety of real-world problems and data sets.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understand different methods for random number generation	K1
2	Understanding of the need for the development process to initiate the real problem.	K2
3	Understanding of principle and techniques of simulation methods informed by research direction.	K3
4	Be able to discuss the simulation methods and select the suitable technique on the problems and know how to simulate any discrete system using queuing systems	K3-K5
5	Use a range of commercial software packages to construct, verify and validate models of the given systems	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Simulation and its Types	9 Hours
Simulation: Introduction, appropriate and not appropriate, advantages and disadvantages, components of system, type of systems, model of a system, types of models and steps in simulation study. Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.		
Unit 2	**Models in Simulation**	**9 Hours**
Statistical Models in Simulation: Useful statistical model, discrete distribution, continuous distribution, empirical distribution - Poisson distribution, Uniform distribution, Exponential distribution, Beta distribution, Gamma distribution.		
Unit 3	**Random number and variate**	**9 Hours**
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 4	**Input Modeling**	**9 Hours**
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 5	**Validation of Models**	**9 Hours**
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.		
	Total lecture hours	**45 hours**

Text Books:

1.Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.

Reference Books:

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.

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	L	M	S	S	L	M
CO2	M	S	S	L	M	M	S	M	S	M
CO3	S	L	M	S	L	M	S	L	M	S
CO4	S	L	L	M	M	M	S	M	M	S
CO5	M	S	S	L	M	M	S	M	S	M

*S – Strong, M- Medium, L- Low

Semester 2.4.3. (21UPSTA2E06) - TOTAL QUALITY MANAGEMENT

Course Code	21UPSTA2E06	TITLE OF THE COURSE	L	T	P	C
Elective - 06		TOTAL QUALITY MANAGEMENT	3	-	-	3
Pre- requisite		Fundamental Statistical Analysis	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Develop a thinking towards Quality systems and thinking.
2. Understand Quality in Manufacturing, Service, Health care and Education
3. Relate to Quality in Public Sector.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Apply various statistical tools to measure quality and customer satisfaction	K2-K3
2	Acknowledge the strategic value of leading practices and therefore their implementation	K1-K2
3	Efficiently designing the effective performance measurement system	K3
4	Measure the Return on Quality and Identifying the critical factors to success	K4-K5
5	Acknowledge, Understand, Implement Six Sigma Principles and Understanding the process of benchmarking and planning the benchmarking exercise	K5-K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Need for TQM, evolution of quality, Definition of quality, TQM philosophy – Contributions of Deming, Juran, Crosby, Taguchi and Ishikawa.	**9 Hours**
Unit 2	Vision, Mission, Quality policy and objective, Planning and Organization for quality, Quality policy Deployment, Quality function deployment, Analysis of Quality Costs.	**9 Hours**
Unit 3	Customer focus, Leadership and Top management commitment, Employee involvement – Empowerment and Team work, Supplier Quality Management, Continuous process improvement, Training, performance, Measurement and customer satisfaction.	**9 Hours**
Unit 4	PDSA, The Seven QC Tools of Quality, New Seven management tools, Concept of six sigma, FMEA, Bench Marking, JIT, POKA YOKE, 5S, KAIZEN, Quality circles.	**9 Hours**
Unit 5	Need for ISO 9000 Systems, clauses, Documentation, Implementation, Introduction to QS 9000, Implementation of QMS, Case Studies.	**9 Hours**
	Total lecture hours	**45 hours**

Text Books:

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th edition, First Indian Edition, Cengage Learning, 2012.
2. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.
3. Janakiraman. B and Gopal.R.K., "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.
4. Dale H.Besterfiled (2002): "Total Quality Management", Pearson Education Asia
5. Oakland.J.S (1989): "Total Quality Management", Butterworth–Hcinemann Ltd., Oxford

Reference Books:

1. Narayana V. and Sreenivasan, N.S. (1996): "Quality Management – Concepts and Tasks", New Age International.
2. Zeiri (1991): "Total Quality Management for Engineers", Wood Head Publishers.
3. Juran J.M and Frank M.Gryna Jr.(1982): "Quality Planning and Analysis", TMH, India.
4. Brain Rethery (1993): ISO 9000, Productivity and Quality Publishing Pvt.Ltd.
5. D.Mills(1993): Quality Auditing, Chapman and Hall

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	L	L	M	L	M	S	S	L	M
CO2	S	S	S	L	M	M	S	M	S	M
CO3	M	L	M	S	L	M	S	L	M	S
CO4	L	L	L	M	M	M	S	M	M	S
CO5	M	S	S	L	M	M	S	M	S	M

*S – Strong, M- Medium, L- Low

Semester 2.5. Supportive Paper

Semester 2.5.1. (21UPSTA2S01) - BASIC STATISTICAL METHODS

Course Code	21UPSTA2S01	TITLE OF THE COURSE	L	T	P	C
Supportive- 01		BASIC STATISTICAL METHODS	4	-	-	3
Pre- requisite		Fundamentals of Probability, Concepts of Descriptive Statistics	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Demonstrate the knowledge of probability and the standard statistical distributions
2. Establish the knowledge of fixed sample and large sample statistical properties.
3. Understand the concepts of classical and repeated measures of statistics
4. Interpreting the conception of statistical tests

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Understand the concepts of Statistics, and comprehend some basic knowledge in measures of central tendency and dispersion	K1, K2
2	Summarize the concepts of probability, distribution function and evaluating the applications of Normal distribution.	K2, K3
3	Examine the properties of correlation and the concepts of regression.	K2, K4
4	Integrate the ideas of hypothesis testing for large samples and small samples.	K3, K5
5	Explore the applications of non-parametric tests and sampling techniques.	K2, K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	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.	**9 Hours**
Unit 2	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.	**9 Hours**
Unit 3	Scatter diagram - Karl Pearson's coefficient of correlation - concurrent deviation method - coefficient of determination - Spearman's Rank correlation -Linear regression–fitting of regression lines.	**9 Hours**
Unit 4	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.	**9 Hours**
Unit 5	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	**9 Hours**
	Total lecture hours	**45 hours**

Text Books:

1. Agarwal, B.L. (2013). Basic statistics. Anshan Publications.

Books for reference:

1. Sharma, J.K. (2007). Business Statistics (Second Edition). Pearson Education, New Delhi.
2. Sokal, P.R. and Rohlf, F.J. (1969). Bio Statistics. W.H. Freeman and Co., San Francisco

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	L	M	L	M	S	S	L	M
CO2	M	S	L	M	M	S	M	L	S	L
CO3	S	S	S	L	L	M	L	M	L	S
CO4	S	L	L	M	L	S	L	L	M	L
CO5	S	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 2.5.2. (21UPSTA2S02) - STATISTICS FOR BEHAVIORAL SCIENCES

Course Code	21UPSTA2S02	TITLE OF THE COURSE	L	T	P	C
Supportive 02		STATISTICS FOR BEHAVIORAL SCIENCE	3	-	-	3
Pre- requisite		Basic knowledge in Statistics for Behavioral Science	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Explain the major concepts, theoretical perspectives and empirical findings in psychology	K1
2	Evaluate the major methods of inquiry and statistical analysis in psychology	K5
3	Discuss the ways in which diversity influences psychological processes	K2, K3
4	Critically analyze existing literature on a topic in psychology	K4
5	Design research studies, including the application of statistical procedures	K3, K4
6	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)	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Design of Sampling	9 Hours
Nature and scope of Statistics - characteristics and limitation of Statistics - statistical investigation - preparation of questionnaire by google form - design of sampling - simple random, stratified and systematic sampling - collection of data - primary and secondary data.		
Unit 2	**Classification of Data and Tabulation of Data**	**9 Hours**
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 by manual and Microsoft Excel.		
Unit 3	**Measures of Central Tendency**	**9 Hours**
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 by manual and Microsoft Excel.		
Unit 4	**Skewness and Kurtosis**	**9 Hours**
Concept of Skewness and Kurtosis - Karl Pearson's and Bowley's coefficients of Skewness- moments- coefficients of Skewness and Kurtosis - Simple Problems by manual and Microsoft Excel.		
Unit 5	**Correlation**	**9 Hours**
Correlation: Scatter diagram - simple correlation, Rank correlation. Regression - simple regression lines (without proof) - Tetro choric correlation, Phi coefficient and Kendall's co-efficient - Simple Problems by manual and Microsoft Excel.		
	Total lecture hours	**45 hours**

Text Books:

1. Privitera, G. J. (2011). Statistics for the behavioral sciences. Sage.
2. Tokunaga, H. T. (2018). Fundamental statistics for the social and behavioral sciences. Sage Publications.

Reference Books:

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.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	S	M	M	S	L	M	M	M	S
CO3	M	S	S	M	M	M	S	S	S	M
CO4	M	S	S	M	M	L	S	M	M	S
CO5	S	S	M	L	S	M	S	M	S	S

*S – Strong, M- Medium, L- Low

Semester 2.5.3. (21UPSTA2S03) - PROBABILITY AND STATISTICS FOR SCIENTISTS

Course Code	21UPSTA2S03	TITLE OF THE COURSE	L	T	P	C
Supportive 03		PROBABILITY AND STATISTICS FOR SCIENTISTS	4	-	-	3
Pre- requisite		Fundamentals of Probability, Concepts of Descriptive Statistics	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Exhibit the knowledge of probability and the standard probability distributions
2. Establish the cognition of large sample theory in estimation.
3. Interpret the concepts of statistical quality control and its measures
4. Demonstrate the conception of design of experiments by ANOVA

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Understand the concepts of probability, and comprehend some basic knowledge in conditional expectation and distribution	K1, K4
2	Examine the concepts of probability distributions and sampling distribution and its properties.	K2, K3
3	Summarize the cognitive content of ANOVA measures in design of experiments	K2, K4
4	Integrate the deals of hypothesis testing for large samples and small samples.	K3, K5
5	Explore the applications of control limits and different types of control charts in statistical quality control.	K2, K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	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.	**9 Hours**
Unit 2	Probability distributions – Binomial, Poisson, geometric, uniform, exponential, normal, gamma, beta (generating function, Mean, variance and Simple problems). Sampling distributions - t, f, Chi-square distributions- properties.	**9 Hours**
Unit 3	Estimation: Point estimation – Characteristics of estimation – Interval estimation – Interval estimates of Mean, Standard deviation, proportion, difference in means and ratios of standard deviations.	**9 Hours**
Unit 4	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	**9 Hours**
Unit 5	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.	**9 Hours**
	Total lecture hours	**45 hours**

Text Books:

1. Gupta, S.C., and Kapoor, V. K. (1977). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.

Books for reference:

1. Montgomery, D.C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.
2. Montgomery, D.C., and Runger, G. C. (2010), Applied Statistics and Probability for Engineers, Fifth Edition, John Wiley & Sons, New York.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	L	M	L	M	S	S	L	M
CO2	S	M	L	M	M	S	M	L	S	L
CO3	M	S	S	L	L	M	L	M	L	S
CO4	S	L	L	M	L	S	L	L	M	L
CO5	L	L	L	M	S	L	M	L	S	M

*S – Strong, M- Medium, L- Low

Semester 2.5.4. (21UPSTA2S04) - STATISTICS FOR RESEARCHERS

Course Code	21UPSTA2S04	TITLE OF THE COURSE	L	T	P	C
Supportive 04		STATISTICS FOR RESEARCHERS	3	-	-	3
Pre- requisite		Basics notions of Statistics for Researchers	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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. Present the research effectively in a conference setting and a written publication

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Research design considerations (question formulation, sample selection and randomisation, study design, and research protocols)	K1, K2
2	Data types, and appropriate summaries and graphs of samples and differences	K2, K3
3	Standard errors, confidence intervals and p-values	K4, K5
4	Parametric and nonparametric assumptions and tests	K5, K6
5	Work collaboratively with real data set, demonstrating effective communication and problem-solving skills	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction	9 Hours
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 2	**Random Experiment and Properties**	**9 Hours**
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 3	**Correlation and Linear Regression**	**9 Hours**
Scatter diagram - Karl Pearson's coefficient of correlation - concurrent deviation method coefficient of determination - Spearman's Rank correlation - Linear regression - regression lines.		
Unit 4	**Tests of significance**	**9 Hours**
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 5	**Non-Parametric Tests**	**9 Hours**
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).		

Text Books:

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

Reference Books:

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. Sokal, P. R., and Rohlf, F. J. (1969). Bio Statistics, W.H. Freedom & Co, San Francisco.
4. Snedecor, G. W., and Cochran, W. G. (1967). Statistical Methods, Oxford-IBH, Pvt Co.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	M	M	M	S	M	M	S	M
CO3	S	M	S	L	S	M	M	L	M	M
CO4	M	M	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	S	S	L

*S – Strong, M- Medium, L- Low

Semester 2.6. (21UPSTA2P02) - STATISTICS PRACTICAL II

Course Code	21UPSTA2P02	TITLE OF THE COURSE	L	T	P	C
Core Practical II		STATISTICS PRACTICAL II	4	-	-	3
Pre- requisite		Knowledge in Estimation and Sampling	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:
1. Identify the relation between the point estimation and interval estimation
2. Estimating maximum likelihood function for various measures
3. The concept of multivariate analysis were incorporated

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Generate random samples and study the properties of estimators	K1 - K4
2	Compute advanced statistical estimates	K2 - K4
3	Carry out the significance tests based on multivariate data	K2 - K4
4	Estimate the maximum likelihood function for moments, minimum chi-square, least square	K1 - K3
5	Computing the various Multivariate measures	K1 - K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Estimation

	1. MLE and Standard error of ML estimators. 2. MLE through the method of successive approximation. 3. MLE for truncated distribution. 4. Method of Moments 5. Method of Minimum Chi-square 6. Method of Least square 7. Interval estimation: Confidence interval for mean, 8. Interval estimation - difference of means, 9. Interval estimation - variance and ratio of variances.	**30 Hours**

Multivariate Analysis:

	1. Maximum likelihood estimators of mean vector and dispersion Matrix. 2. Test for mean vector when dispersion matrix in known $\sum$ 3. Hotelling's T^2 statistic. 4. Test for covariance matrix 5. Principal component analysis. 6. Canonical correlation and canonical variables. 7. Classification problems. 8. Factor Analysis.	**30 Hours**

Text Books:

1. Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis (Third Edition). Wiley – Inter science, New York

Reference Books:

1. Casella G and Berger R L, (2002). Statistical Inference, Second Edition, Thompson Learning, New York. (Reprint, 2007).
2. Rohatgi, V. K and Saleh, A.K.Md.E, (2011), An Introduction to Probability and Statistics Second Edition, John Wiley & Sons, New York.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	M	S	S	M	S	M	S	S
CO2	S	M	M	M	M	S	M	M	S	M
CO3	M	M	S	L	S	M	M	L	M	M
CO4	S	M	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	S	S	L

*S – Strong, M- Medium, L- Low

Semester 2.7. (06PHR01) - Human Rights and Duties (No credit calculated)

Semester 3

Semester 3.1. (21UPSTA3C08) - HYPOTHESIS TESTING

Course Code	21UPSTA3C08	TITLE OF THE COURSE	L	T	P	C
Core 08		HYPOTHESIS TESTING	4	-	-	4
Pre-requisite		Sampling, Distribution, Estimation Theory	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Draw inference about unknown population parameters based on random samples
2. Impart knowledge on statistical hypothesis
3. Understand Neyman-Pearson fundamental lemma for testing statistical hypothesis
4. Understand the test procedures MPT, UMPT, LMPT, LRT and SPRT
5. Inculcate various parametric and non-parametric, sequential test procedures

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Make inferences about statistical unknown population parameters based onrandom samples	K1, K5
2	Formulate statistical hypothesis of one and multiple parameter exponential distributions	K3
3	Test statistical hypothesis by LR test procedure.	K3, K4
4	Determine the size of critical region and power of test function.	K5
5	Solve real life problems by applying suitable parametric / nonparametric Sequential testing procedures.	K3, K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Testing of hypotheses**	**12 hours**
Testing of hypotheses: simple and composite hypotheses – Critical Region - Type I Error – Type II Error - level of significance - Power and Size of a Test - Most powerful test – Neyman-Pearson lemma for Randomized and Non-Randomized Cases - Monotone Likelihood Ratio Property - Uniformly Most Powerful Tests - Applications to standard statistical distributions.		
Unit:2	**Exponential Family of Distributions**	**12 hours**
Generalization of Neyman-Pearson fundamental lemma (Statement Only)- Tests for One-Parameter Exponential Family of Distributions and Multi - Parameter - Exponential Family of Distributions - Locally Most Powerful (LMP) test - LMP unbiased test.		
Unit:3	**Likelihood Ratio Tests**	**12 hours**
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:4	**Non-Parametric Tests**	**12 hours**
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:5	**Sequential Probability Ratio Tests**	**12 hours**
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.		

Text Book(s)

1	Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY.
2	Casella, G. and Berger, R.L. (2002). Statistical Inference (Second Edition). Thompson Learning, New York. (Reprint, 2007).
3	Rajagopalan M and Dhanavanthan P, (2012), Statistical Inference, PHI Learning Pvt. Ltd., New Delhi.
4	Gibbons J.D and S. Chakraborty (2010) "Non – Parametric Statistical Inference", 3rd Edition, Marcel Dekker.

Reference Books

1	Lehmann, E. L. (1986). Testing Statistical Hypotheses, Second Edn., John Wiley & Sons, NY
2	Goon, A. M., Gupta, M. K., Das Gupta. B. (1973). An outline of Statistical Theory, Vol. II, World Press, Calcutta.

3	Rao, C.R. (1973). Linear Statistical Inference and Its Applications, 2nd Edn., Wiley Eastern Ltd.
4	Gupta, S. C., and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, SultanChand & Sons, New Delhi
5	Rajagopalan, M., and Dhanavanthan, P. (2012). Statistical Inference, PHI Learning Pvt., Ltd.,New Delhi.
6	Conover, W. J. (1980). Practical Nonparametric Statistics, Second Edn., John Wiley & Sons,NY.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	L	S	M	S	S	M	S	M	S	S
CO2	S	M	M	M	M	S	M	M	S	M
CO3	M	M	S	L	S	M	M	L	M	M
CO4	S	M	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	S	S	L

*S-Strong; M-Medium; L-Low

Semester 3.2. (21UPSTA3C09) - STATISTICAL QUALITY CONTROL

Course Code	21UPSTA3C09	TITLE OF THE COURSE	L	T	P	C
Core 09		STATISTICAL QUALITY CONTROL	4	-	-	4
Pre- requisite		Elementary probability theory, sampling theory	Syllabus Version		2021-2022	

Course Objectives

1. To help students understand the concepts underlying statistical quality control and to develop their ability to apply those concepts to the design and management of quality control processes in industries.
2. To obtain some basic knowledge in use of various control charts for quality control, process control
3. Discussing the overview of state of the art of quality control methodologies

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Understanding the quality in production and service organizations, through the use of adequate statistical techniques	K2
2	Evaluating the shifts on control charts	K5
3	Demonstrating the sampling plans of attributes by various measures	K3, K4
4	Summarizing the ideas of single and double variable sampling plan	K4
5	Enumerating continuous sampling plan and product control	K5, K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction of Control Charts	12 Hours
Modified control charts - Basic principles and design of cumulative charts. Moving-average and geometric moving-average control charts - sloping control chart. Process capability analysis using histogram, probability plotting and control chart - Process capability ratios- use and their interpretations.		
Unit 2	**Control Charts for Small Shifts**	**12 Hours**
Specification limits and tolerance limits - Modified control charts - Basic principles and design of cumulative-sum control charts – Concept of V-mask procedure – Tabular CUSUM charts. Construction of Moving range, moving-average and geometric moving-average control charts.		
Unit 3	**Attributes and Variables Sampling Plans**	**12 Hours**
Acceptance sampling: Sampling inspection by attributes – single, double and Sequential sampling plans – Rectifying Inspection. Measures of performance: OC, ASN, ATI and AOQ functions. Concepts of AQL, LTPD and IQL. Dodge – Roming and MIL-STD-105D tables. Sampling inspection by variables - known and unknown sigma variables sampling plan - Merits and limitations of variables sampling plan - Derivation of OC curve – determination of plan parameters.		
Unit 4	**Variable Sampling**	**12 Hours**
Variable Sampling: Assumptions, Single and Double Variable Sampling Plans. Application of Normal and Non-central t - Distributions in Variable Sampling.		
Unit 5	**Product Control**	**12 Hours**
Continuous Sampling and Sequential Sampling- Continuous sampling plans by attributes - CSP-1 and its modifications - concept of AOQL in CSPs - Multi-level continuous sampling plans - Operation of multi-level CSP of Lieberman and Solomon – Wald - Wolfowitz continuous sampling plans. Sequential Sampling Plans by attributes – Decision Lines - OC and ASN functions.		
	Total lecture hours	**60 hours**

Text Books:

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.
4. Burr. I.W (1953) "Engineering Statistics and Quality Control", McGraw Hill, New Delhi.
5. Biswas. S (1996) "Statistics of Quality Control, Sampling Inspection and Reliability", New Age Intl. Publisher

Reference Books:

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), Dhanpat Rai 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

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	S	S	S	S	S	S
CO2	L	S	L	L	S	L	L	S	L	L
CO3	S	L	M	S	L	M	S	L	M	S
CO4	M	S	S	M	S	S	M	S	S	M
CO5	S	M	M	S	M	M	S	M	M	S

*S – Strong, M- Medium, L- Low

Semester 3.3. (21UPSTA3C10) - DEMOGRAPHY AND VITAL STATISTICS

Course Code	21UPSTA3C10	TITLE OF THE COURSE	L	T	P	C
Core 10		DEMOGRAPHY AND VITAL STATISTICS	4	-	-	4
Pre- requisite		Elementary Statistics, population studies	Syllabus Version		2021-2022	

Course Objectives

The aim objectives of this course are to:

1. Comprehensive survey of the field of social demography the scientific study of population
2. Population will be examined in relation to its sociological determinants and consequences.
3. Relationship between population and issues such as urbanization, family change, population aging and health, economic growth, and the environment.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understanding the scope of Demography and population transition theory	K2
2	Demonstrate the measurement of population in vital statistics	K5
3	Evaluating the basic measurements of mortality and fertility	K3, K4
4	Summarizing the measurements of nuptiality and some special distribution in population	K4
5	Estimating the population, mortality, migrations by projections	K5, K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction Demography	12 Hours

	Development and scope of demography - Demographic data: Sources of demographic Statistics, Current status - Chandrashekar- Deming index - Adjustment of age data – Use of Whipple – Myer and UN indices - Population size and growth in India - Trends and differentials in world population – Health Surveys and use of hospital statistics – Population transition theory.	
Unit 2	**Population Theories**	**12 Hours**
	Population composition, dependency ratio, Sex ratio and its implication on a population. Sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Stable Populations, Calculation of the age distribution of a stable population	
Unit 3	**Measurements of Mortality**	**12 Hours**
	Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates. Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and Uses of Life Tables. Abridged Life Tables. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Population regulation programs in India.	
Unit 4	**Concept of Migration and Metropolitan growth**	**12 Hours**
	Nuptiality and its measurements. 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.	
Unit 5	**Population Projections**	**12 Hours**
	Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections. Ageing of the population.	
	Total lecture hours	**60 hours**

Text Books:

1. Benjamin, B. (1975) Demographic Analysis, George Allen and Unwin, London.
2. Cox, D.R. (1978) Demography, Cambridge University Press, Cambridge.

Reference Books:

1. Gibbs, J.P. (2012) Urban Research Methods. Literary Licensing, LLC, White Fish, USA.
2. Keyfliz, N. and Caswell, H. (2006). Applied Mathematical Demography. Springer, New York.
3. Kumar, R. (1986) Technical Demography. Wiley Eastern, New Delhi.
4. Misra, B.D. (1982). An Introduction to the Study of Population. South East Asia Publishers, Madras.
5. Spiegelman, M. (1969): Introduction to Demographic Analysis. Harvard University Press, Harward.
6. Wolfenden, H.H. (1954). Population Statistics and their Compilation, University of Chicago Press, Chicago.

Mapping with Programmes Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	S	S	S	S	S	S	S
CO2	L	S	L	L	S	L	L	S	L	L
CO3	S	L	M	S	L	M	S	L	M	S
CO4	M	S	S	M	S	S	M	S	S	M
CO5	S	M	M	S	M	M	S	M	M	S

*S – Strong, M- Medium, L- Low

Semester 3.4. (21UPSTA3C11) - ECONOMETRICS AND TIME SERIES ANALYSIS

Course Code	21UPSTA3C11	TITLE OF THE COURSE	L	T	P	C
Core 11		ECONOMETRICS AND TIME SERIES ANALYSIS	4	-	-	4
Pre- requisite		Basic knowledge in linear models and their properties	Syllabus Version		2021-2022	

Course Objectives

The aim objectives of this course are 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. Describe Components of Time Series
5. By Box & Jenkins modeling

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	A broad knowledge of regression analysis relevant for analyzing economic data.	K1, K2
2	Interpretation and critical evaluation of the outcomes of empirical analysis	K5
3	Elementary procedures for model validation in the single equation context.	K3
4	Understand and be able to apply the concepts and methods underlying the analysis of univariate time series, and the context for interpretation of results	K2, K4
5	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.	K6

K1 - Remember; **K2** - Understand; **K3** -Apply; **K4** - Analyze; **K5**-Evaluate; **K6** – Create

Unit 1	Preliminaries on Econometrics	12 Hours
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 2	**Generalized Least Squares and Properties**	**12 Hours**
Homoscedasticity and Heteroscedasticity: Nature – OLS Estimation and Its Consequences – Detection: Informal and Formal Methods (Park, Goldfeld and Quand t test) - Remedial Measures – Method of GLS. Concept of Multicollinearity: Effects, Detection and Remedial Measures - Problem of Aggregation		
Unit 3	**Autocorrelation and Properties**	**12 Hours**
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 4	**Additive and Multiplicative models**	**12 Hours**
Definitions, Applications, Techniques and 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 5	**Stationary Process**	**12 Hours**
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.		
	Total lecture hour	**60 Hours**

Text Books

1. Gujarati, D. N., Dawn C Porter and Sangeetha Kunasekar, (2016), Basic Econometrics, Fifth Edition, McGraw Hill Publisher, New York.
2. Anderson, T. W. (2011). The Statistical Analysis of Time Series. John Wiley & Sons.
3. James. H. Stock and Mark. W. Watsop (2010) "Introduction to Econometrics", 3rd Edition, Addison – Wesley Series in Economics.

Reference Books

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.

Mapping with Programmes Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	S	M	M	S	M	M	M	M	S
CO3	S	M	S	L	M	M	S	M	S	M
CO4	M	S	M	M	S	L	M	M	S	S
CO5	S	S	M	L	S	M	S	M	S	M

*S – Strong, M- Medium, L- Low

Semester 3.5. Elective III

Semester 3.5.1. (21UPSTA3E07) - CATEGORICAL DATA ANALYSIS

Course Code	21UPSTA3E07	TITLE OF THE COURSE	L	T	P	C
Elective - 07		CATEGORICAL DATA ANALYSIS	3	-	-	3
Pre- requisite		Fundamentals of data and data source	Syllabus Version		2021-2022	

Course Objects

The main objectives of this course are to:

1.The course covers models for categorical data, two way and multi way contingency tables, homogeneity and independence
2. Generalized linear models for categorial data, logistic regression, log linear models for categorial data and diagnostics of models.
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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	This course is devoted to the analysis of data in which the response variables are categorical: either qualitative or quantitative with a limited number of values. Explanatory variables can be categorical or continuous.	K2
2	Give an account of the sampling strategies for categorical data;	K3
3	Analyze a two-way contingency table	K4
4	Carry out exact inference for a three-way contingency table; build and apply logit and log linear models	K5
5	Be able to interpret the results in practical examples.	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Linear Models	9 Hours

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 2	**Multinomial Response Models**	**9 Hours**

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

Unit 3	**Generalized linear models**	**9 Hours**

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

Unit 4	**Contingency tables**	**9 Hours**

Introduction to contingency tables: 2×2 and r×c tables -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 5	**Log-linear models**	**9 Hours**

Polytomous logit 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.

	Total lecture hours	**45 hours**

Text Books:

1. Agresti, Alan (1996). An Introduction to Categorical Data Analysis, Wiley.

Reference Books:

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

Mapping with Programmes Outcomes

Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	M	M	S	L	M	M
CO2	L	M	S	L	M	S	L	L	M	L
CO3	S	S	S	L	L	M	M	L	L	M
CO4	S	M	L	M	L	S	L	L	M	M
CO5	M	M	L	M	S	L	M	L	S	L

*S – Strong, M- Medium, L- Low

Semester 3.5.2. (21UPSTA3E08) - STATISTICAL METHODS FOR EPIDEMIOLOGY

Course Code	21UPSTA3E08	TITLE OF THE COURSE	L	T	P	C
Elective - 08		STATISTICAL METHODS FOR EPIDEMIOLOGY	3	-	-	3
Pre- requisite		Basics of vital statistics	Syllabus Version		2021-2022	

Course Objectives

1. To figure out what causes different health outcomes in different groups of people.
2. To determine the frequency of specific health problems, identify patterns in occurrences of the problem
3. Identify and address the concepts of population health

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Summarizing the measures of disease frequency	K2
2	Determining the occurrence of diseases with models of transmission	K3
3	Analyzing the epidemiological and clinical data by odds and risk factors	K4
4	Evaluating the experimental design of epidemiology	K5
5	Enumerating the planning and the design of clinical trials	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	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.	**9 Hours**
Unit 2	Epidemiologic concepts of diseases: Factors which determine the occurrence of diseases - models of transmission of infection - incubation period - disease spectrum and herd immunity	**9 Hours**
Unit 3	Analysis of Epidemiologic and Clinical Data: Studying association between a disease and a characteristic: (a) Types of studies in Epidemiology and Clinical Research (i) Prospective study (ii)Retrospective study (iii) Cross-sectional data, (b) Dichotomous Response and Dichotomous Risk Factor: 2x2 Tables (c) Expressing relationship between a risk factor and a disease (d) Inference for relative risk and odds ratio for 2x2 table	**9 Hours**
Unit 4	Experimental Epidemiology: Clinical trial & community survey - 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.	**9 Hours**
Unit 5	Planning and design of clinical trials, Phase I, II, and III trials. Consideration in planning a clinical trial, designs for comparative trials. Sample size determination in fixed sample designs.	**9 Hours**
	Total lecture hours	**45 hours**

Text Books:

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.

Reference Books:

1. Armitage. (1980). Sequential medical trials, Charles C. Thomas
2. Bailey, N.T.J. (1987). The Biomathematics of Malaria.Oxford University Press, Incorporated
3. Biswas, S. (1995). Applied Stochastic Processes: A Biostatistical and Population Oriented Approach, Wiley Eastern Ltd.
4. Collett, D. (2003). Modelling Survival Data in Medical Research, Chapman & Hall/CRC.
5. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
6. Elandt Johnson R.C. (1971). Probability Models and Statistical

Mapping with Programmes Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	L	M	M	M	S	L	M	M
CO2	L	M	S	L	M	S	L	L	M	L
CO3	S	S	S	L	L	M	M	L	L	M
CO4	S	M	L	M	L	S	L	L	M	M
CO5	M	M	L	M	S	L	M	L	S	L

*S – Strong, M- Medium, L- Low

Semester 3.5.3. (21UPSTA3E09) – BIO STATISTICS

Course Code	21UPSTA3E09	TITLE OF THE COURSE	L	T	P	C
Elective - 09		BIO STATISTICS	3	-	-	3
Pre- requisite		Basics of distribution theory and regression analysis	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Introduce the basics of biostatistics
2. Understand and apply statistical methods for the design of biomedical research and analysis of biomedical research data
3. Understand and use mathematical and statistical theory underlying the application of bio statistical methods;
4. Learn to participate in a research team setting in study design, data coordinating and management, and statistical analysis and reporting of study results
5. Participate in a research team in the development and evaluation of new and existing statistical methodology.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation.	K5
2	Select from, use, and interpret results of, the principal methods of statistical inference and design.	K5
3	Communicate the results of statistical analyses accurately and effectively.	K5
4	Make appropriate use of statistical software.	K5
5	Read and learn new statistical procedures independently.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** –Create

Unit 1	Statistical Methods in Clinical Trials	9 Hours

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)

Unit 2	**Exposure Association and Contingency Tables**	**9 Hours**

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 3	**Test of Significance**	**9 Hours**

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

Unit 4	**Linear and Logistic Regression**	**9 Hours**

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

Unit 5	**Survival Analysis**	**9 Hours**

Introduction to Survival: Concepts of time, Censoring-different types of censoring- right and left, Survival function-hazard function and their relationships; censoring Type I and II (definition only). Nonparametric methods estimating survival distributions; parametric survival models– Basic life time distributions - Exponential, Weibull, Log-normal, Gamma, Generalized Gamma, Log-logistic and Gompertz.

Total lecture hours **45 hours**

Text Books:

1. Rossi R.J. (2010). Applied Biostatistics for Health Sciences, Wiley.
2. David G. K., and Klein, M. (2012). Survival analysis - A Self-Learning Text, Third edition, Springer.
3. Bernard Rosner, (2016), Fundamentals of biostatistics, Cengage Learning, 8th edition

Reference Books:

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. Tilman M. Davies (2016). The Book of R: A First Course in Programming and Statistics
4. Lee, E. T., and Wenyu, J. (2003). Statistical methods for Survival Data Analysis, Third Edition, John Wiley & Sons.

Mapping with Programmes Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	M	M	M	S	M	M	S
CO2	M	S	S	L	M	M	S	M	S	M
CO3	M	M	S	M	M	S	M	M	M	S
CO4	S	M	M	S	S	L	M	M	S	M
CO5	S	S	M	S	M	S	L	M	M	M

*S – Strong, M- Medium, L- Low

Semester 3.6 - Supportive Paper

Semester 3.6.1. (21UPSTA3S01) - DESCRIPTIVE STATISTICS

Course Code	**21UPSTA3S01**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Supportive 01		**DESCRIPTIVE STATISTICS**	**3**	**-**	**-**	**3**
Pre- requisite		Basics notions of descriptive statistics	**Syllabus Version**		**2021-2022**	

Course 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Descriptive Statistics, tools that they are confronted with on a daily basis through the media, which use them to excess.	K1
2	Analyze statistical data graphically using frequency distributions and cumulative frequency distributions.	K2, K3
3	Analyze statistical data using measures of central tendency, dispersion and location.	K4, K5
4	Organize, manage and present data.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Collection of Data	9 Hours
Concept of primary and secondary data-Collection of Data - Classification and Tabulation of data - Diagrammatic and Graphical representation of data using MS-Excel.		
Unit 2	**Measures of Central Tendency**	**9 Hours**
Measures of Central tendency: mathematical and positional - Measures of Dispersion - Relative measures of dispersion - skewness and kurtosis Sheppard's corrections- Simple problems.		
Unit 3	**Mathematical and Statistical Probability**	**9 Hours**
Basic concepts of probability- Random experiment- Sample space - discrete probability, independent events - Mathematical and Statistical probability - Axiomatic approach to probability - Conditional Probability and its related theorem – Bayes' theorem and its applications - Simple problems.		
Unit 4	**Discrete and Continuous Random Variables**	**9 Hours**
Definition of Random variables - Discrete and continuous random variables - Distribution function – probability mass function and probability density function with illustrations and properties of random variables, univariate transformations with illustrations.		
Unit 5	**Correlation and Regression**	**9 Hours**
Simple linear correlation and regression - Karl Pearson's correlation coefficient and its properties - Regression equations - their properties spearman's Rank correlation co-efficient - Simple problems		
	Total Lecture Hours	**45 Hours**

Text Books:

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

Reference Books:

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.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	L	S	M	S	L
CO2	M	M	L	L	S	M	M	M	M	S
CO3	S	L	S	M	S	M	S	M	M	M
CO4	S	M	S	L	M	L	M	L	M	S
CO5	M	M	M	L	S	M	S	M	L	L

*S – Strong, M- Medium, L- Low

Semester 3.6.2. (21UPSTA3S02) - COMPUTER ORIENTED STATISTICAL METHODS

Course Code	21UPSTA3S02	TITLE OF THE COURSE	L	T	P	C
Supportive 02		COMPUTER ORIENTED STATISTICAL METHODS	3	-	-	3
Pre- requisite		Knowledge in object-oriented language	Syllabus Version		2021-2022	

Course Objects

The main objectives of this course are 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.

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Summarizing the measures of central tendency and dispersion	K2
2	Solving the problem of distribution and its properties	K3
3	Fitting the curve for linear, quadratic, exponential and power curve	K4
4	Evaluating the measure of association between variables	K5
5	Enumerating the tests of significance of mall and large samples	K4, K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Introduction	9 Hours

Introduction to Computing - Computer Codes and Arithmetic Overview of BASIC - Sampling and Frequency Distribution - Measures of Central Tendency - Measures of Dispersion - Moments - Simple Problems.

Unit 2	Random Variable	9 Hours

Concept of a Random Variable - Discrete Probability Distributions - Binomial Distribution - Geometric Distributions - Poisson distribution – Negative binomial - Properties and Numerical problems.

Unit 3	Method of Least Squares	9 Hours

Curve Fitting and Function Approximations: Least square error criterion - Linear and nonlinear Regression – Method of Least Squares - Fitting of linear, quadratic, Exponential and power curves and their problems.

Unit 4	Correlation and properties	9 Hours

Measure of association between two variables - Coefficient of Correlation and its mathematical properties – Concept of Rank Correlation - Multiple Correlation - Partial Correlation.

Unit 5	Tests of Significance	9 Hours

Tests of Significance: Small sample and large sample tests - t Test, F Test, paired tests, Variance Ratio Test (F-test) and x2 test for test for independence of attributes - ANOVA one way and two-way classifications simple problems using Excel.

Text Books:

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.

Reference Books:

1. Afifi, A. A., & Azen, S. P. (2014). Statistical analysis: a computer-oriented approach. Academic press.
2. Crump, P. P. (1982). Statistical analysis: a computer-oriented approach.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	S	M	S	M
CO2	M	S	S	L	S	M	M	M	M	S
CO3	S	M	S	M	S	L	S	L	S	M
CO4	M	S	S	M	M	L	M	L	M	S
CO5	M	M	M	L	S	M	S	M	M	S

*S – Strong, M- Medium, L- Low

Semester 3.6.3. (21UPSTA3S03) - STATISTICS FOR ECONOMICS

Course Code	21UPSTA3S03	TITLE OF THE COURSE	L	T	P	C
Supportive 03		STATISTICS FOR ECONOMICS	3	-	-	3
Pre-requisite		Basic knowledge in Statistics and Economics	Syllabus Version		2021-22	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Use graphical and numerical methods to calculate and illustrate descriptive statistics.	K1,K2
2	Use the basic concepts of probability and Bayes Theorem.	K3
3	Identify the statistical concepts in questions about economic models.	K5
4	Identify the appropriate regression model to apply to an economics dataset.	K4
5	Identify common problems which may affect regression analyses.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Preliminaries on Statistics	9 hours

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 2	**Presentation of Statistical Data**	**9 hours**

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 3	**Measures of Central Tendency and Dispersion**	**9hours**

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 4	**Correlation and Regression Models**	**9 hours**

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:5	**Time Series Analysis and Index Numbers**	**9 hours**

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.

	Total Lecture Hours	**45 hours**

Books for Study

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, 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.

Reference Books

1. Gupta S. C., and Kapoor, V. K. (2014). Fundamentals of Applied Statistics, Fourth Edition, Sultan Chand and Sons, New Delhi.
2. Saxena, H.C. (1967). Elementary Statistics, Sultan Chand & Co., New Delhi.

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	S	M	S	M
CO2	M	S	S	L	S	M	M	M	M	S
CO3	S	M	S	M	S	L	S	L	S	M
CO4	M	S	S	M	M	L	M	L	M	S
CO5	M	M	M	L	S	M	S	M	M	S

*S-Strong; M-Medium; L-Low

Semester 3.6.4. (21UPSTA3S04) - MATHEMATICAL ECONOMICS

Course Code	21UPSTA3S04	TITLE OF THE COURSE	L	T	P	C
Supportive 04		MATHEMATICAL ECONOMICS	3	-	-	3
Pre-requisite		Basic Knowledge in Mathematical Economics	Syllabus Version		2021-22	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Use graphical and numerical methods to calculate and illustrate descriptive statistics.	K1, K2
2	Use the basic concepts of Mathematical Economics.	K2, K3
3	Identify the statistical concepts in questions about economic models.	K5
4	Identify the appropriate regression model to apply to an economics dataset.	K3, K4
5	Identify common problems which may affect regression analyses.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Average and Marginal Cost Curves	9 Hours
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 2	**Rate of Commodity substitution and properties**	**9 Hours**
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 3	**Production Function**	**9 Hours**
Production Function - Constant Product Curves: Isoquants - Shape of Isoquants and Ridge Lines-Least Cost Combination (constrained Cost Maximization) - Constrained Profit Maximization - Homogeneous Function - Cobb-Douglas production function - Elasticity of substitution- Elasticity of substitution of Linearly Homogeneous Function - C.E.S. Function.		
Unit 4	**Multiple Production**	**9 Hours**
Multiple Production by Monopolist - Discriminating monopoly -Duopoly - Consumer's Surplus - Producer's Surplus.		
Unit 5	**Input-Output Analysis**	**9 Hours**
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.		
	Total Lecture Hours	**45 Hours**

Text Books:

1.Allen, R.G.D. (2008). Mathematics for Economists, ELBS series, London.

Reference Books:

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

*S – Strong, M- Medium, L- Low

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	S	M	S	S
CO2	M	M	M	M	M	S	M	M	M	S
CO3	S	M	S	L	M	M	S	L	M	M
CO4	M	L	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	M	S	L

Semester 3.7. (21UPSTA3P03) - STATISTICS PRACTICAL III (USING R)

Course Code	21UPSTA3P03	TITLE OF THE COURSE	L	T	P	C
Core: Practical III		STATISTICS PRACTICAL III (R PROGRAMMING)	-	-	4	3
Pre- requisite		Knowledge in object-oriented language and statistical methods	Syllabus Version		2021-2022	

Course Objective

The main objectives of this course are to:

1. Impart knowledge on statistical computation using real data sets
2. In-still knowledge to apply theory into practice
3. Understand the theory through practical oriented training
4. Identify the problem and evaluating suitable test statistic for the data

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Perform the basic operations of R Language.	K1-K3
2	Use appropriate plots, charts and diagrams for all kinds of statistical data.	K1-K3
3	Perform statistical test procedures using R software.	K3, K4
4	Write programming codes for the methods in Statistical quality control.	K3-K5
5	Write and execute programming codes for multivariate analysis, Design of experiments.	K5-K6

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyse; K5 - Evaluate; K6 – Create

Exercise under Descriptive Statistics, Correlation, Regression and Test of significance. 1. Summary Statistics. 2. Correlation coefficient. 3. Linear Regression equations. 4. Problems for the One and Two sample Z – test for mean and proportion. 5. Problems for the paired t-test. 6. Problems of t test for mean for one sample and two samples. 7. Problems of F test for equality of variances 8. Problems for the chi-square test independence of attributes. 9. Problems for the chi-square goodness of fit test.	**16 Hours**
Exercise under Standard Probability Distributions 1. Fitting of Binomial Distribution. 2. Fitting of Poisson Distribution. 3. Fitting of Normal Distribution.	**12 Hours**
Exercise under ANOVA and Design of Experiments 1. One – way and two – way analysis of variance 2. CRD, RBD and LSD	**8 Hours**
Exercise under statistical quality control 1. Construction of control charts for mean, range and standard deviation of and X bar, R charts. 2. Construction of control charts for attributes viz. p, c, np and u charts.	**12 Hours**
Exercise under Multivariate Analysis 1. Multiple regressions. 2. Logistic Regression Analysis. 3. Principal component Analysis and Factor Analysis 4. Cluster Analysis	**12 Hours**
Text Books: 1. Purohit, S. G., Gore, S. D., and Deshmukh, S. R. (2009). Statistics Using R, Narosa Publishing House, New Delhi. 2. Dalgaard, P. (2008). Introductory Statistics with R, Second Edition, Springer 3. Crawley, M, J. (2007). The R Book, John Wiley and Sons Private Ltd., NY. Reference Books 1 De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY. 4. Johnson, R. A., and Wichern, D. W. (2013). Applied Multivariate Statistical Analysis Sixth Edition, Pearson New International Edition 5. De Vries, A., and Meys, J. (2016). R For Dummies, Second Edition, John Wiley & Sons Private Ltd, NY. 6. Quick, J. M. (2010). Statistical Analysis with R, Packt Publishing Ltd., UK. 7. Everitt, B. S., and Hothorn, T. (2010). A Handbook of Statistical Analyses Using R, Second Edition, Chapman and Hall/CRC Press.	

Reference Books:

1. Goon, A. M., Gupta, M. K., and Dasgupta, B. (1989). An Outline of Statistical Theory World Press, Calcutta.
2. Montgomery, D. C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	L	M	S	M	M	S	M	S	M
CO2	M	M	S	S	L	S	S	L	M	L
CO3	M	L	M	S	M	S	L	M	S	M
CO4	S	M	S	M	S	M	S	S	M	L
CO5	M	S	M	S	S	M	L	S	M	M

*S – Strong, M- Medium, L- Low

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

Semester 4

Semester 4.1. (21UPSTA4C12) - LINEAR MODELS AND DESIGN OF EXPERIMENTS

Course Code	**21UPSTA4C12**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Core 12		**LINEAR MODELS AND DESIGN OF EXPERIMENTS**	**4**	**-**	**-**	**4**
Pre-requisite		Knowledge on Analysis of Variance and Basics of Design of Experiments	**Syllabus Version**		**2021-22**	

Course Objectives

The main objectives of this course are to:

1. To teach the students to understand the theoretical concepts of the general linear model andits types.
2. To make the students familiar with various experimental designs.
3. To make the students understand some advanced concepts of design of experiments like factorial experiments.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Remember and understand the theoretical underpinning of the linear model, analysis of variance and design of experiments.	K1, K2
2	Understand the type of any given experiment and the type of design apt for its analysis.	K2
3	Apply various designs of experiments in several practical situations and evaluateits results.	K3, K5
4	Make further analyses which are specific to the objectives of any experiment	K4
5	Create new types of designs as per the requirements and study their behavior whileproceeding to the research.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	Linear Models and Analysis of Variance	12 hours
Linear models – Definition – Fixed, Random and mixed effects models - Estimability of a linear parametric function - Best Linear Unbiased Estimator – Linear parametric function and the condition for its estimability -Test for Linear Hypothesis - Gauss - Markov theorem - Analysis of variance for one – way and two - way classification with one and more than one (equal) observations per cell with interaction.		
Unit:2	**ANCOVA and Complete Basic Designs**	**12 hours**
Principles of Experimentation - Review of Basic Designs and CRD-RBD-LSD with their merits and limitations. Analysis of covariance (ANCOVA) - description of the method in the case of one and two concomitant variables. Multiple Comparison and Multiple Range Tests: Need – Tukey's Test – Fisher's Least Significance Difference method, Duncan's multiple range tests, Neyman-Kauls test.		
Unit:3	**Concepts of Experiments and Confounding**	**12 hours**
Factorial experiments – 2^n and 3^n experiments and their analysis – Construction complete and partial confounding - $(n \times p)$ Asymmetrical Factorial Experiment Analysis.		
Unit:4	**Fractional Factorial and Response Surface Designs**	**12 hours**
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 - Concept of response surface experiments - First order Response surface designs – steepest ascent method – Second-order Response surface designs.		
Unit:5	**Incomplete Block Designs**	**12 hours**
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.		
	Total Lecture Hours	**60 hours**

Text Books	
1	Montgomory, D.C. (2012). Design and Analysis of Experiments, Eighth Edition, John Wiley & Sons, NY.
2	Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition, New Age International Private Ltd., New Delhi
3	Graybill, F.A. (1961): An Introduction to Linear Statistical Models, McGraw Hill Co., London.
4	Graybill, F. A. (2000). Theory and Applications of Linear Models, Duxbury Press, First Edition, MA.
5	Peterson, R. G. (1985). Design and analysis of experiments, Marcel Dekker, NY.
6	Paneerselvam, R. (2012). Design and Analysis of Experiments, PHI Learning Private Ltd., New Delhi.
7	Parimal Mukhopadhyay (2015) "Applied Statistics", 2nd Edition, Allied(P) Ltd Kolkata.
Reference Books	

1	Fisher, R.A. (1966). The Design of Experiments, 8th Edition, Oliver and Boyd, London.
2	Federer, W. T. (1967). Experimental Design: Theory and Application, Indian Edition, Oxford and IBH Publishing Co., New Delhi.
3	Kempthorne, O. (1965). The Design and Analysis of Experiments, Wiley Eastern India Limited, New Delhi
4	Cochran, W.G. and Cox, G.M. (1992). Experimental Designs, Second Edition, John Wiley & Sons, New York.
5	Nigam, A. K., Puri, P. D., and Gupta, V. K. (1988). Characterizations and Analysis of Block Designs, John Wiley & Sons, NY.
6	John, P.W.M. (1971). Statistical Design of Experiments, Macmillan Co., NY.
7	Joshi, D.D. (1987). Linear Estimation and Design of Experiments, First Edition, New Age International (P) Ltd, New Delhi.
8	Searle, S.R. and Gruber, M. H. J. (2016). Linear Models, Second Edition, John Wiley & Sons,Inc.,

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	S	M	S	M
CO2	M	S	S	L	S	M	M	M	M	S
CO3	S	M	S	M	S	L	S	L	S	M
CO4	M	S	S	M	M	L	M	L	M	S
CO5	M	M	M	L	S	M	S	M	M	S

*S-Strong; M-Medium; L-Low

Semester 4.2. (21UPSTA4C13) - STOCHASTIC PROCESSES

Course Code	21UPSTA4C13	TITLE OF THE COURSE	L	T	P	C
Core 13		STOCHASTIC PROCESSES	4	-	-	4
Pre- requisite		Calculus and Consent of the Instructor	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	The student has basic knowledge about stochastic processes in the time domain.	K1
2	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.	K4-K6
3	The student also knows about queuing 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.	K3-K5
4	To introduce fundamental probability concepts.	K1, K2
5	To illustrate these probability concepts with examples from Management Sciences.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	**Introduction of Stochastic Process**	**12 Hours**
Introduction to Stochastic Processes - Definition and examples-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 2	**Differential Equations**	**12 Hours**
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 3	**Branching Processes**	**12 Hours**
Branching Processes – Discrete time Branching Process- Galton –Watson Branching Process -Properties of Generating Functions – Extinction Probabilities –Distribution of Total Number of Progeny. Concept of Weiner Process.		
Unit 4	**Renewal Processes**	**12 Hours**
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 5	**Queuing processes**	**12 Hours**
Queuing processes; General Description M/M/1 models with finite and infinite capacities Waiting time and busy period for both steady state transient behavior; Birth and Death Processes in queuing theory; multi-channel model M/M/S; Embedded techniques applied to M/G/I and GI/M/I as particulars cases; Erlangian Queues.		
	Total Lecture Hours	**60 hours**

Text Books:

1. Medhi, J. (2017). Stochastic Processes, Fourth Edition, New Age International (P) Ltd. New Delhi.
2. Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris, (2013), Fundamentals of Queueing Theory, 4th Edition, Wiley Publisher.
3. Bhat U.N., and Miller G.K (2002) "Elements of Applied Stochastic Processes", 3rd Edition, Wiley – Interscience.

Reference Books:

1. Bhat, U. N., and Miller, G. K. (2002). Elements of Applied Stochastic Processes, Third Edition, Wiley -Interscience.
2. Box, G.E.P., and Jenkins, G.M., (1976). Time Series Analysis - Forecasting and Control. Holden-Day San Francisco.
3. Karlin,S. and Taylor,H.M. (1975). A First Course in Stochastic Process, Second Edition, Academic Press.
4. Parzen, E. (1962). Stochastic Processes, Holland-Day
5. Srinivasan, S.K, Introduction to Stochastic processes and their applications.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	M	S	S	L	M	S
CO2	S	S	S	M	S	M	S	S	L	M
CO3	L	M	S	S	M	S	M	S	L	L
CO4	M	M	M	S	S	M	S	M	S	S
CO5	S	S	M	M	M	L	L	L	S	S

*S – Strong, M- Medium, L- Low

Semester 4.3- Elective IV

Semester 4.3.1. (21UPSTA4E10) - APPLIED REGRESSION ANALYSIS

Course Code	**21UPSTA4E10**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective- 10		**APPLIED REGRESSION ANALYSIS**	**3**	**-**	**-**	**3**
Pre- requisite		Fundamentals of Linear Regression, Correlation and their Properties	**Syllabus Version**		**2021-2022**	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	The first objective is to provide a thorough foundation for simple linear regression as a tool for exploring the linear relationship between two variables.	K1, K2
2	They will also use the model to estimate means and predict individual responses, and construct intervals for the estimates and predictions.	K4
3	Students will then move onto multiple linear regression where more than one predictor is included in the model.	K3, K4
4	They will learn how estimation, evaluation, checking assumptions, estimating means, and predicting individual responses generalize to this setting.	K4, K5
5	Students will learn about using variable transformations and interactions to incorporate nonlinear and non-additive relationships in the model.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Simple Regression Model	9 Hours
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 2	**Diagnostic Check and Correction**	**9 Hours**
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 3	**Multiple Regression**	**9 Hours**
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 4	**Non-Linear Regression**	**9 Hours**
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 5	**MLR and GLM Model**	**9 Hours**
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.		
	Total Lecture Hours	**45 Hours**

Text Books

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, John Wiley & Sons, NY.

Reference Books

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, John 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.

Mapping with Programmes Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	M	M	M	S	M	M	S	M
CO3	S	M	S	L	S	M	M	L	M	M
CO4	M	M	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	S	S	L

*S – Strong, M- Medium, L- Low

Semester 4.3.2. (21UPSTA4E11) - STATISTICAL COMPUTATIONS USING PYTHON
(Practical Lab Based Course)

Course Code	**21UPSTA4E11**	**TITLE OF THE COURSE**	**L**	**T**	**P**	**C**
Elective - 11		**STATISTICAL COMPUTATIONS USING PYTHON** (Practical Lab Based Course)	**3**	**-**	**-**	**3**
Pre- requisite		Knowledge in Basic Programming and Multivariate Analysis	**Syllabus Version**		**2021-2022**	

Course Objectives

The main objectives of this course are to:
1. To understand the basic programming principles of Python language
2. To be familiar with the operations of data
3. To analyze data which includes knowing how to import data, explore it, analyze it, learn from it, visualize it, and ultimately generate easily shareable reports.
4. Explore and execute the machine learning concepts for real time data using Python

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understand the concepts of Python and its operations.	K1, K2
2	Performing the operations of Python by essential modules.	K4
3	Evaluate supervised learning by different techniques.	K3, K4
4	Enumerate the process of unsupervised learning by pre-processing of data.	K4, K5
5	Incorporate the ideas of clustering by the method of unsupervised learning algorithms.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit 1	Basics of Python Type of variables, data types, lists, control statements, functions, classes, files and exceptions. • Program to implement Functions. • Program to perform Basic Operations on Sequence objects.	**9 Hours**
Unit 2	Essential Modules in Python Jupyter Notebook, Numpy, Scipy, Matplotlib, Pandas, mglearn • Program to perform Operations on Sequence annotation objects. • Program to perform Operations on Sequence Input/Output. • Program to perform Operations on Multiple Sequence Alignment objects.	**9 Hours**
Unit 3	Supervised Learning Classification and Regression, k-Nearest Neighbors, k-Nearest Neighbors, Decision Trees, Neural Networks	**9 Hours**
Unit 4	Unsupervised Learning - 1 Pre-processing and Scaling, Scaling training, Dimensionality Reduction, Feature Extraction, and Manifold Learning	**9 Hours**
Unit 5	Unsupervised Learning -2 Clustering: k- Means clustering, Agglomerative Clustering.	**9 Hours**
	Total lecture hours	**45 hours**

Text Books:

1. Introduction to Machine Learning with Python – A Guide for Data Scientists by Andreas C.Muller & Sarah Guido (2017), O'Reilly
2. Machine Learning in Python: Essential Techniques for Predictive Analysis by Micheal Bowles (2015), Wiley
3. Python Crash Course: A hands-on, Project- Based Introduction to Programming by Eric Mathes (2016), no starch press

Reference Books:

1. Python for Probability, Statistics and Machine Learning (second edition) (2019) by Jose Unpingco, Springer
2. Practical Statistics for Data Scientists (second edition) (2020) by Peter Bruce, Andrew Bruce & Peter Gedeck, O'Reilly

Mapping with Programmes Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	M	M	M	S	M	M	S	M
CO3	S	M	S	L	S	M	M	L	M	M
CO4	M	M	S	M	S	L	L	L	S	L
CO5	S	S	M	L	L	M	S	S	S	L

*S – Strong, M- Medium, L- Low

Semester 4.3.3. (21UPSTA4E12) - BAYESIAN METHODS

Course Code	21UPSTA4E12	TITLE OF THE COURSE	L	T	P	C
Elective - 12		BAYESIAN METHODS	3	-	-	3
Pre-requisite		Basic knowledge in Bayesian methods	Syllabus Version		2021-22	

Course Objectives

The main objectives of this course are 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.

Expected Course Outcomes

	On the successful completion of the course, student will be able to:	Related Ks
1	Understand Bayesian thinking.	K2
2	Use prior information and Bayes' rule in probability and statistical inference problems.	K5
3	Apply Bayesian inference methods to common parameters (binomial, Normal) and to relationships between variables.	K6
4	Compare these with frequency methods.	K4
5	Understand Bayesian testing of statistical hypotheses.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create

Unit:1	**Decision Theory**	**9 hours**
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:2	**Priori Distribution**	**9 hours**
Subjective probability – its interpretation and evaluation - Subjective determination of prior distributions - Improper prior, noninformative prior, invariant prior, Jeffreys non informative prior and natural conjugate prior – family of distributions admitting natural conjugate prior.		
Unit:3	**Loss Functions**	**9 hours**
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:4	**Interval Estimation**	**9 hours**
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:5	**Bayesian Hypotheses**	**9 hours**
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.		
	Total Lecture Hours	**45 hours**

Books for Study

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).

Reference Books

1	Gelman,A., Carlin,J.B., Stern,H.B. and Rubin, D.B.(2013). Bayesian Data Analysis (Third Edition). CRC press.
2	Ghosh,J.K., Delampady, M. and Samanta, T. (2010). An Introduction to Bayesian Analysis: Theory and Methods. Springer Verlag, New York.
3	Lee, P.M. (2012). Bayesian Statistics – An Introduction (Fourth Edition). John Wiley & Sons, London.
4	Leonard, T. and J.S.J. Hsu. (1999). Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers. Cambridge University Press, London.
5	Robert, C.P. (1994). The Bayesian Choice: A Decision-Theoretic Motivation (Second Edition). Springer Verlag, New York.
6	Robert,C.P. and Casella,G. (2004). Monte Carlo Statistical Methods (Second Edition). Springer Verlag, New York. (Reprint 2010).

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	M	M	S	M	S	M
CO2	M	S	S	L	S	M	M	M	M	S
CO3	S	M	S	M	S	L	S	L	S	M
CO4	M	S	S	M	M	L	M	L	M	S
CO5	M	M	M	L	S	M	S	M	M	S

*S-Strong; M-Medium; L-Low

Semester 4.4. (21UPSTA4P04) - STATISTICS PRACTICAL IV

Course Code	21UPSTA4P04	TITLE OF THE COURSE	L	T	P	C
Practical IV		STATISTICS PRACTICAL IV	4	-	-	3
Pre- requisite		Fundamentals of Design of experiments, statistical quality control and hypothesis testing	Syllabus Version		2021-2022	

Course Objectives

The main objectives of this course are to:

1. Students will be able to make inferences using evidence and background knowledge.
2. Determining the capability of the manufacturing process.
3. Demonstrate the ability to use the methods of statistical process control.

Expected Course Outcomes

On the successful completion of the course, student will be able to:		Related Ks
1	Design, use, and interpret exponentially weighted moving average and moving average control charts	K1, K2
2	Demonstrate the plausibility of Pre-specified ideas about the parameters of the model by examining the area of hypothesis testing.	K4
3	Enumerate the notion of a parametric model and point estimation of the parameters of those models.	K3, K4
4	Apply various designs of experiments in several practical situations and evaluateits results.	K4, K5
5	Create new types of designs as per the requirements and study their behavior while proceeding to the research.	K4

➢ **Statistical Quality Control** ➢ CUSUM Control Chart ➢ Modified Control chart ➢ Moving Average Control chart ➢ Sloping Control Chart ➢ Acceptance sampling plan (Single and double) ➢ Determination of AOQ for CSP–1, CSP–2 plans for given parameter values, OC curve for CSP–1 plan. ➢ Using Dodge–Romig tables to draw OC, AOQ and ASN curve for single and double sampling plans.	**20 Hours**

Hypothesis testing ➢ Construction of randomized and non randomized MP, UMP and UMPU tests of hypotheses and drawing the power curves. ➢ Construction of SPRT and its OC and ASN curves. ➢ Critical regions and power curves ➢ Testing hypothesis (i) Simple Hypothesis (ii) One sided and two-sided alternatives ➢ Non-Parametric Tests: ➢ Sign Test, Kolmogorov - Smirnov Test, Median Test, Wald-Wolfowitz Run Test, Mann-Whitney U-Test and Test for Randomness. ➢	**20 Hours**

Design of Experiments	**20 Hours**
➢ Multiple Comparison tests (Least Significant Difference (LSD) test, Bonferonni's test) ➢ Missing Data Analysis- one and two observations in RBD ➢ Missing Data Analysis- one and two observations in LSD ➢ 2^4, 3^2 factorial experiments ➢ Fractional factorial experiments ➢ Complete confounding in 2^4, 3^2 factorial experiments ➢ Partial confounding in 2^4, 3^2 factorial experiments ➢ Split plot design ➢ BIBD ➢ Youden Square Design ➢ Analysis of Covariance – RBD – One Concomitant Variable.	

Text Books:

1. Montgomery, D. C. (2009). Introduction to Statistical Quality Control, Sixth Edition, Wiley India, New Delhi.
2. Das, M. N., and Giri, N. C. (2011). Design and Analysis of Experiments, Second Edition, New Age International Private Ltd., New Delhi
3. Rohatgi, V. K. (1976). Introduction to Probability Theory and Mathematical Statistics, John Wiley & Sons, NY.

Semester 4.5. (21UPSTA4C14) - Project/Dissertation