Curriculum

for

Master of Science (MS)
in
Statistics and Data Science

Sessions: 2023-24, 2024-25, 2025-26, 2026-27

Department of Statistics and Data Science
Jahangirnagar University

INTRODUCTION

The Department of Statistics and Data Science (SDS) at Jahangirnagar University is committed to fostering statistical methods in its theoretical, applied, and in scientific research in alignment with the rapidly growing field of data science.

It is one of the four departments with which Jahangirnagar University started its journey in 1970. Initially, it was named as the "Department of Information Science", and it had changed to the "Department of Statistics" later on. In today's age of information, the adoption of new statistical methods and tools has grown enormously. The field of statistics is continuously evolving in response to the remarkable increase in demand for statistical thinking and methodology in scientific research. Keeping this in mind, the department is renamed in 2023 as "Department of Statistics and Data Science".

The department offers BSc (Honors), MS, MPhil, and PhD degrees in Statistics and Data Science. It also offers a Master of Professional Studies (MPS) in Applied Statistics and Data Science (ASDS) under weekend program. Our regular programs cover a broad range of courses focusing on theory, applications, and computation using different statistical software such as Python, R, SPSS, STATA, etc. In addition, research in the department focuses on advanced data science tools and covers several areas such as Data Mining, Machine Learning, Computer Intensive Statistics, Big Data, Spatial Data Analysis, Data Analytics, Meta-analysis, Biostatistics, Bioinformatics, Epidemiology, Demography, Design of Experiment, Time Series Modelling, Econometrics, Advance Statistical Modelling, etc.

The faculty members are well-experienced and well-known in their own field of research at home and abroad. In terms of number of students, faculty members, and facilities available in the department, it is now one of the best departments in the country.

It regularly updates its courses, which opens the window of opportunity for our students to get acquainted with the recent developments in the field and become able to implement the knowledge in their professional lives. We are very proud of our long track record of producing graduates who have become leaders in many areas of scientific and human endeavor. Many of them are working in diversified organizations both at home and abroad with a reputation. The percentage of graduates and their performance in different sectors, especially in the Teaching, Research, Financial Service, and Public Service sectors, are splendid. Some of the former students of the department are working in top-ranked universities around the globe.

It has been publishing a journal entitled "Journal of Statistical Studies" since 1982. The department moves forward with a good pace in order to encompass the state-of-art of

development in statistics and data science globally. The department is well-equipped with computer facilities (with two big computer labs) for the students. The department has a seminar library with approximately 7,500 books and journals in total.

In addition to its core academic program, the department organizes lectures, seminars, and workshops throughout the year. Sports, cultural, and other co-curricular activities are well-organized, which portray national pride, prejudice, and heritage. Students are also supported with different scholarships available in the department.

Part A

1. **Title of the Academic Program:** MS in Statistics and Data Science

2. **Name of the University:** Jahangirnagar University

3. **Vision of the University:** Promoting and advancing world-class higher education in the University.

4. **Mission of the University:**

- **Mission 1:** Creating skilled and trained human resources by providing technology-based education, fostering communication with the outside world, and expanding national and international collaboration and research activities.
- **Mission 2:** Contributing effectively to the enhancing higher education standards in Bangladesh in alignment with international benchmarks.
- **Mission 3:** Ensuring quality advanced higher education for all classes of citizens irrespective of religion, caste, creed, and gender.

5. **Name of the Program Offering Entity:** Department of Statistics and Data Science.

6. **VISION of the Program Offering Entity**

Establish the department as a center for excellence in Statistics and data science through evidence-based education, scientific research and IT-based practice to address emerging global challenges.

7. **MISSION of the Program Offering Entity**

M1	Provide in-depth knowledge on statistical theories and data science techniques to the students so that they add value to the existing knowledge of Statistics and Data Science.
M2	Promote creative and critical thinking among students, enabling them to develop statistical theories and data science techniques and apply them in their professional lives.
M3	Deliver through high-quality teaching-learning process the richness of multidisciplinary knowledge and skills so that the students can be prepared with modern techniques to serve the needs of the country.

8. Objectives of the Program Offering Entity

1. To equip students with cutting-edge knowledge of statistics and data science to develop their skills, particularly with computer intensiveness.
2. To foster specializing in advanced statistical and data science techniques to apply in scientific research aspects of the modern age and improve their employability in national and worldwide job markets.
3. To enhance leadership skills in the domains of statistics and data science, integrating analytical ability with ethics, collaboration, and communication, aiming to provide value-added insights on a global scale.

9. Name of the Degree: MS in Statistics and Data Science

10. Description of the Program:

The Department of Statistics and Data Science, JU adopts the following program structure for its master's degree:

- **Master's by Coursework:** Master's by Coursework involves taught courses of 41 credits. The duration at this level will be one academic year of full-time study and comprises 2 semesters.
- **Master's by Mixed Mode:** A Mixed-mode Master's involves 41 credits taught component and a research component involving a thesis/dissertation of 4 credits. A total of 45 credits. The duration at this level will be one and a half academic years of full-time study and comprises 3 semesters.

11. Graduate Attributes:

The attitudes of the graduates of the Department are aligned with the goals of outcome-based education, which intends to prepare its graduates not only with knowledge in Statistics and Data Science but also with the skills and attitudes necessary for success in various aspects of life. The following are the anticipated characteristics that graduates at the Department of Statistics and Data Science might cultivate under the outcome-based education framework:

- **Critical thinking and problem-solving:** Graduates should develop the ability to analyze information critically and think independently to solve challenges with a logical and analytical mindset using different programming languages and statistical tools.
- **Effective communication skills:** Graduates should be capable of expressing ideas clearly, both in written and oral forms, and be able to communicate with diverse audiences through meaningful dialogue.
- **Teamwork, collaboration, and Timeliness:** Graduates are expected to collaboratively work in group settings, demonstrating the timely execution often demanded in professional environments.

- **Adaptability and lifelong learning:** Graduates should be open to acquiring new knowledge, skills, and attitudes throughout their careers to continuously update their competencies in response to evolving professional and societal demands.

- **Ethical and social responsibility:** Graduates are expected to demonstrate ethical decision-making, integrity, and a sense of responsibility towards their communities. They should understand the societal implications of their actions and contribute positively to the well-being of society.

12. Program Education Objectives (PEO)

PEO1	To impart comprehensive academic and practical literacy in statistics, data science, and related fields.
PEO2	To promote lateral thinking by way of enabling the students to come out with simple solutions for complex statistical and data science problems that support critical analysis and decision-making process.
PEO3	To facilitate modern tools and techniques used in statistics and data science required for conducting scientific research and preparing them for employment.
PEO4	To foster innovative thinking for understanding not only how to apply certain methods, but when and why they are appropriate.
PEO5	To incorporate ethics and develop leadership skills, teamwork with effective communication, and time management so that they add value at the global arena.

13. Program Learning Outcome (PLO)

PLO1	Students will learn the fundamentals of statistics and data science with applications.
PLO2	Students will be equipped with probability theory and will perform statistical inference in several circumstances, interpreting the results in an applied context.
PLO3	Students will create different quantitative and qualitative models to solve real-world problems in appropriate contexts.
PLO4	Students will apply statistical software packages, languages, and algorithms to process and analyze data appropriately.
PLO5	Students will design, carry out, and disseminate original research at the leading edge of statistics and data science discipline.

14. Mapping MISSION with PEOs

PEOs	Mission 1	Mission 2	Mission 3
PEO1	3	3	1
PEO2	2	3	3
PEO3	2	3	3
PEO4	2	3	2
PEO5	1	2	3

Degree of strength: 3 – High; 2 – Medium; 1 – Low

15. Mapping PLOs with PEOs

PLO/PEO	PEO1	PEO2	PEO3	PEO4	PEO5
PLO1	3	3	3	2	1
PLO2	3	2	3	3	1
PLO3	3	2	3	3	2
PLO4	2	2	3	3	3
PLO5	1	3	3	3	3

Degree of strength: 3 – High; 2 – Medium; 1 – Low

Formulation of Course Code:

Each course contains a 4-digit subject code followed by a 4-digit course code.

- The subject code is taken from the 'International Standard Classification of Education' published by UNESCO Institute for Statistics. In the document, the subject code for Statistics is 0542, for Mathematics is 0541, for ICT courses is 0610, for Health-related courses is 0988, for Environment is 0521, etc.

- Following the subject code, each course contains a 4-digit course code. The first digit represents the year, the second digit is used for the semester number, and the last two digits represent the course serial number.

  Example: The course code **0542-5101** represents the first Statistical and Data Science course of Semester 1 of Year 5.

Part B

1. **Structure of the Curriculum**

   a. Duration: **By Coursework:** Years: 1.0 Semesters: 2

   By Mixed Mode: Years: 1.5 Semesters: 3

   b. Admission requirement: Based on JU Admission Ordinance.

   c. Credit requirement: **By Coursework:** 41 credits

   By Mixed Mode (Dissertation): 45 credits

   d. Total class-weeks in a semester: 14 weeks

   e. Minimum CGPA requirements for post-graduation: CGPA 2.50 on a scale of 4.0

   f. Max academic years of completion: Course work: 2 years; Mixed-Mode: 2.5 years

   g. Category of Courses:

By Coursework

Sl. #	Course category	Description	Type	Number of courses	Total credits
1	Core courses	Include courses that characterize the discipline	Theory	4	4×3 = 12
			LAB	4	4×1 = 4
2	Elective courses	Include courses for specialization within Statistics and Data Science	Theory	6	6×3 = 18
			LAB	6	6×1 = 6
3	Viva voce	Viva	-	1	1×1 = 1
Total Credit			**-**	**-**	***41***

By Mixed Mode with Dissertation

Sl. #	Course category	Description	Type	Number of courses	Total credits
1	Core courses	Include courses that characterize the discipline	Theory	4	4×3 = 12
			LAB	4	4×1 = 4
2	Elective courses	Include courses for specialization within Statistics and Data Science	Theory	6	6×3 = 18
			LAB	6	6×1 = 6
3	Capstone course	Thesis/Dissertation	-	1	1×4 = 4
5	Viva voce	Viva	-	1	1×1 = 1
Total Credit			**-**	**-**	***45***

h. Year & Semester wise distribution of courses:

By Coursework (duration 1 year)

Year 5: Semester 1

Course Code	Course Title	Course Type	Credit
0542-5101	Advanced Multivariate Analysis	CORE	3
0542-5102	Big Data Analytics	CORE	3
Optional 1	From list of optional courses	Elective	3
Optional 2	From list of optional courses	Elective	3
Optional 3	From list of optional courses	Elective	3
LAB 1	LAB related to 0542-5101	LAB	1
LAB 2	LAB related to 0542-5102	LAB	1
LAB 3	LAB related to Optional 1	LAB	1
LAB 4	LAB related to Optional 2	LAB	1
LAB 5	LAB related to Optional 3	LAB	1
Total credit			**20**

Optional course for Semester 1:

Course Code	Course Title	Course Type	Credit
0542-5111	Longitudinal Data Analysis	Elective	3
0542-5112	Advanced Categorical Data Analysis	Elective	3
0542-5113	Advanced Time-series Analysis	Elective	3
0542-5114	Meta Analysis	Elective	3
0542-5115	Spatial Data Analysis	Elective	3
0610-5116	Computer Intensive Statistics	Elective	3
0610-5117	Bioinformatics and Genetic Algorithm	Elective	3
0314-5118	Advanced Demography and Population Studies	Elective	3
0532-5119	Remote Sensing and GIS	Elective	3
0521-5120	Environmental Statistics and Modeling	Elective	3

LAB/Practical Courses for Semester 1

Course Code	Course Title	Course Type	Credit
0542-5121	LAB - Advanced Multivariate Analysis	LAB	1
0542-5122	LAB - Big Data Analytics	LAB	1
0542-5123	LAB - Longitudinal Data Analysis	LAB	1
0542-5124	LAB - Advanced Categorical Data Analysis	LAB	1
0542-5125	LAB - Advanced Time-series Analysis	LAB	1
0542-5126	LAB - Meta Analysis	LAB	1
0542-5127	LAB - Spatial Data Analysis	LAB	1
0610-5128	LAB - Computer Intensive Statistics	LAB	1
0610-5129	LAB - Bioinformatics and Genetic Algorithm	LAB	1
0314-5130	LAB - Population Studies	LAB	1
0532-5131	LAB - Remote Sensing and GIS	LAB	1
0521-5132	LAB - Environmental Statistics and Modeling	LAB	1

Year 5: Semester 2

Course Code	Course Title	Course Type	Credit
0542-5201	Advanced Classical and Bayesian Inference	CORE	3
0610-5202	Deep Learning	CORE	3
Optional 1	From list of optional courses	Elective	3
Optional 2	From list of optional courses	Elective	3
Optional 3	From list of optional courses	Elective	3
LAB 1	LAB related to 0542-5201	LAB	1
LAB 2	LAB related to 0610-5202	LAB	1
LAB 3	LAB related to Optional 1	LAB	1
LAB 4	LAB related to Optional 2	LAB	1
LAB 5	LAB related to Optional 3	LAB	1
0542-5200	Viva-Voce	Viva	1
Total credit			**21**

Optional for Semester 2:

Course Code	Course Title	Course Type	Credit
0542-5211	Incomplete Data Analysis	Elective	3
0542-5212	Robust Statistics	Elective	3
0542-5213	Semiparametric Regression	Elective	3
0542-5214	Applied Stochastic Process and Stochastic Simulation	Elective	3
0542-5215	Advanced Design of Experiments	Elective	3
0542-5216	Multivariate and Clustered Survival Data Analysis	Elective	3
0610-5217	Advanced Data Visualization	Elective	3
0610-5218	Artificial Intelligence	Elective	3
0912-5219	Epidemiological Modelling for Public Health	Elective	3

LAB/Practical Courses for Semester 2

Course Code	Course Title	Course Type	Credit
0542-5221	LAB - Advanced Classical and Bayesian Inference	LAB	1
0610-5222	LAB - Deep Learning	LAB	1
0542-5223	LAB - Incomplete Data Analysis	LAB	1
0542-5224	LAB - Robust Statistics	LAB	1
0542-5225	LAB - Semiparametric Regression	LAB	1
0542-5226	LAB - Applied Stochastic Process and Stochastic Simulation	LAB	1
0542-5227	LAB - Advanced Design of Experiment	LAB	1
0542-5228	LAB - Multivariate and Clustered Survival Data Analysis	LAB	1
0610-5229	LAB - Advanced Data Visualization	LAB	1
0610-5230	LAB - Artificial Intelligence	LAB	1
0912-5231	LAB - Epidemiological Modelling for Public Health	LAB	1

By Mixed Mode with Dissertation (duration 1.5 year)

Year 5: Semester 1

Course Code	Course Title	Course Type	Credit
0542-5101	Advanced Multivariate Analysis	CORE	3
0542-5102	Big Data Analytics	CORE	3
Optional 1	From list of optional courses	Elective	3
Optional 2	From list of optional courses	Elective	3
Optional 3	From list of optional courses	Elective	3
LAB 1	LAB related to 0542-5101	LAB	1
LAB 2	LAB related to 0542-5102	LAB	1
LAB 3	LAB related to Optional 1	LAB	1
LAB 4	LAB related to Optional 2	LAB	1
LAB 5	LAB related to Optional 3	LAB	1
Total credit			**20**

Optional course for Semester 1:

Course Code	Course Title	Course Type	Credit
0542-5111	Longitudinal Data Analysis	Elective	3
0542-5112	Advanced Categorical Data Analysis	Elective	3
0542-5113	Advanced Time-series Analysis	Elective	3
0542-5114	Meta Analysis	Elective	3
0542-5115	Spatial Data Analysis	Elective	3
0610-5116	Computer Intensive Statistics	Elective	3
0610-5117	Bioinformatics and Genetic Algorithm	Elective	3
0314-5118	Advanced Demography and Population Studies	Elective	3
0532-5119	Remote Sensing and GIS	Elective	3
0521-5120	Environmental Statistics and Modeling	Elective	3

LAB/Practical Courses for Semester 1

Course Code	Course Title	Course Type	Credit
0542-5121	LAB - Advanced Multivariate Analysis	LAB	1
0542-5122	LAB - Big Data Analytics	LAB	1
0542-5123	LAB - Longitudinal Data Analysis	LAB	1
0542-5124	LAB - Advanced Categorical Data Analysis	LAB	1
0542-5125	LAB - Advanced Time-series Analysis	LAB	1
0542-5126	LAB - Meta Analysis	LAB	1
0542-5127	LAB - Spatial Data Analysis	LAB	1
0610-5128	LAB - Computer Intensive Statistics	LAB	1
0610-5129	LAB - Bioinformatics and Genetic Algorithm	LAB	1
0314-5130	LAB - Population Studies	LAB	1
0532-5131	LAB - Remote Sensing and GIS	LAB	1
0521-5132	LAB - Environmental Statistics and Modeling	LAB	1

Year 5: Semester 2

Course Code	Course Title	Course Type	Credit
0542-5201	Advanced Classical and Bayesian Inference	CORE	3
0610-5202	Deep Learning	CORE	3
Optional 1	From list of optional courses	Elective	3
Optional 2	From list of optional courses	Elective	3
Optional 3	From list of optional courses	Elective	3
LAB 1	LAB related to 0542-5201	LAB	1
LAB 2	LAB related to 0610-5202	LAB	1
LAB 3	LAB related to Optional 1	LAB	1
LAB 4	LAB related to Optional 2	LAB	1
LAB 5	LAB related to Optional 3	LAB	1
0542-5200	Viva-Voce	Viva	1
Total credit			**21**

Optional for Semester 2:

Course Code	Course Title	Course Type	Credit
0542-5211	Incomplete Data Analysis	Elective	3
0542-5212	Robust Statistics	Elective	3
0542-5213	Semiparametric Regression	Elective	3
0542-5214	Applied Stochastic Process and Stochastic Simulation	Elective	3
0542-5215	Advanced Design of Experiments	Elective	3
0542-5216	Multivariate and Clustered Survival Data Analysis	Elective	3
0610-5217	Advanced Data Visualization	Elective	3
0610-5218	Artificial Intelligence	Elective	3
0912-5219	Epidemiological Modelling for Public Health	Elective	3

LAB/Practical Courses for Semester 2

Course Code	Course Title	Course Type	Credit
0542-5221	LAB - Advanced Classical and Bayesian Inference	LAB	1
0610-5222	LAB - Deep Learning	LAB	1
0542-5223	LAB - Incomplete Data Analysis	LAB	1
0542-5224	LAB - Robust Statistics	LAB	1
0542-5225	LAB - Semiparametric Regression	LAB	1
0542-5226	LAB - Applied Stochastic Process and Stochastic Simulation	LAB	1
0542-5227	LAB - Advanced Design of Experiments	LAB	1
0542-5228	LAB - Multivariate and Clustered Survival Data Analysis	LAB	1
0610-5229	LAB - Advanced Data Visualization	LAB	1
0610-5230	LAB - Artificial Intelligence	LAB	1
0912-5231	LAB - Epidemiological Modelling for Public Health	LAB	1

Year 6: Semester 1

Thesis group students must complete their dissertation in the first semester of the second year. Therefore, for Thesis group students, it takes 3 semesters (1.5 years) to complete the Master of Science in Statistics and Data Science.

Course Code	Course Title	Course Type	Credit
0542-6101	Dissertation (Evaluation of Thesis – 70% & Oral presentation – 30%)	Capstone/ Thesis	4
Total credit			**4**

Modalities:

The selected students will complete the Thesis work under the supervision of a supervisor assigned by the Department. The Thesis supervisors will be assigned at the beginning of the 1st semester of year 5. The Thesis group students will be selected by the respective Examination Committee of the Department as per the set criteria by the Department/ University.

Assessment:

The Thesis will be evaluated as per the following criteria:

- Evaluation of Thesis – 70%
- Oral presentation – 30%

Part C
Description of Courses

Year 5: Semester 1

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5101	Advanced Multivariate Analysis	CORE	**Value:** 3.0	100

1. Rationale of the Course:

This course is designed to provide students with an in-depth understanding of sophisticated statistical techniques that are essential for analyzing complex data sets and drawing meaningful conclusions. The course also emphasizes the application of multivariate techniques in various domains, fostering critical thinking and enhancing problem-solving abilities among students.

2. Course Objectives:

Advanced Multivariate Analysis is designed to develop a comprehensive understanding of complex statistical techniques and their applications. The major objectives of this course include:

- To gain a deep understanding of a wide range of multivariate analysis techniques.
- To develop the skills to analyze and interpret high-dimensional data sets.
- To apply advanced multivariate analysis techniques to real-world problems.
- To develop critical thinking skills to assess the validity and reliability of multivariate analysis results.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to gain proficiency in a range of advanced multivariate analysis techniques.	3	3	3	1	2
2. Students should be able to interpret complex multivariate analysis results effectively.	2	3	3	2	1
3. Students should be able to visualize and present multivariate data utilizing graphical techniques.	2	2	3	3	2
4. Students should be able to apply advanced multivariate analysis techniques to real-world problems.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Multivariate Multiple Regression**: Meaning, Functional form and Underlying Assumptions. Likelihood Ratio Test for Regression Parameters, Predicting Multivariate Multiple Regression, Confidence Ellipse and Prediction Ellipse from Bivariate Responses.	Classroom Lecture and Discussion	2, 3
3-4	**Multilevel Modeling:** Conceptual Framework of Multilevel Modeling, Hierarchically Structured Data, Analytical Problems with Multilevel Data, Advantages and Limitations of Multilevel Modeling.	Classroom Lecture and Discussion	1, 2
5-6	**Linear Multilevel Models**: Concept of Fixed, Mixed and Random Effect Multilevel Mode, Constructing Multilevel Models, Assumptions, Formulations and Estimation of Two-Level and Three-Level Models, Fixed and Random Coefficients, Cross Level Interactions, Measurement Centering, Hypothesis Testing, Model Comparison, Level 1 and Level 2 Variances.	Classroom Lecture and Discussion	1, 2
7-8	**Mixed Models:** Multivariate Probit Model, the Dale Model, Hybrid Marginal-conditional Specification, Mixed Marginal-conditional Model, Categorical Outcomes, Marginal Multivariate Model, Linear Mixed Model, Estimation and Inference for the Marginal Model, Inference for the Random Effects, Model Families in General, generalized linear mixed models, generalized estimation equation, alternating logistic regression.	Classroom Lecture and Discussion	1, 2
9-10	**Analysis of Covariance Structure:** Covariance Structure, Hypotheses about Covariance Structure, Model of Covariance Structure Analysis, Scope of Covariance Structural Analysis, Illustration of Likelihood Ratio Test, Tests of Covariance Structure Based on Union-Intersection Principle, Structural Analysis	Classroom Lecture and Discussion	1, 2, 4
11-12	**Generalized Estimating Equations (GEE):** Define GEE. GEE as an extends of GLM. Correlation structures (e.g., exchangeable, autoregressive, unstructured) and their implications. Estimating model parameters using the GEE approach. Interpreting estimated coefficients and their significance. Adequacy of the GEE model. Methods for identifying influential observations and outliers.	Classroom Lecture and Discussion	1,2 ,4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
13-14	**Independent Component Analysis (ICA):** Basic Concept on ICA. Identifiability of the ICA Model, Ambiguities of ICA, preprocessing for ICA, Principles of ICA Estimation: Maximization of Non-Gaussianity Using Kurtosis and Negentropy, Minimization of Mutual Information, Maximum Likelihood Estimation. Image Processing using ICA.	Classroom Lecture and Discussion	3, 4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Jonhnson, R. A. and Wichern, D. W. (2007). Applied Multivariate Statistical Analysis, 6th Edition, Pearson, London, UK.
ii. Anderson, T. W. (2003). Introduction to Multivariate Analysis, 3rd Edition, John Wiley, New York.

Supplementary Readings:

i. Afifi, A., May, S., Donatello, R., & Clark, V. A. (2019). Practical multivariate analysis. Chapman and Hall/CRC.
ii. Izenman, A. J. (2008). Modern Multivariate Statistical Techniques, Regression, Classification and Manifold Learning, Springer-Verlag, Newwork.
iii. Finch, W. Holmes, Bolin, Jocelyn E., & Kelley, Ken. (2019). Multilevel Modeling Using R, 2nd Edition, CRC Press.
iv. Hyvarinen, A. Karunen, J. and Oja, E. (2001). Independent Component Analysis, New York: Wiley.
v. Everitt, B., & Hothorn, T. (2011). An introduction to applied multivariate analysis with R. Springer Science & Business Media.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5102	Big Data Analytics	CORE	**Value:** 3.0	100

1. Rationale of the Course:

This course aims to equip students with essential knowledge and skills in handling large and complex datasets, which are becoming increasingly crucial in today's data-driven world. By understanding the fundamentals of Big Data, its technologies, and applications, students will be prepared to navigate and leverage data effectively in various domains. This course addresses the growing demand for professionals who can harness the power of Big Data to make informed decisions, solve real-world problems, and drive innovation across industries.

2. Course Objectives:

The specific objectives of this course included:

- To gain an understanding of the concept of Big Data and its relevance in today's data-driven world.
- To define the key features and characteristics that distinguish Big Data from traditional data.
- To explore the value and potential benefits of utilizing Big Data in various industries and sectors.
- To investigate the historical development of Big Data and the challenges it has faced throughout its evolution.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to understand the definition, features, value, development, and challenges of Big Data.	3	3	2	1	2
2. Students will be able to demonstrate proficiency in using Big Data technologies like Hadoop, Spark, and IoT.	3	3	2	3	3
3. Students will be able to effectively manage and process data, including real-time analytics.	2	3	3	2	2
4. Students will be able to master data integration, workflow management, and data governance practices.	1	2	3	3	2
5. Students will be able to explore advanced solutions such as cloud-based platforms, deep learning, and ethical considerations in Big Data projects.	1	1	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Introduction of Big Data:** Dawn of the Big Data Era, Definition and Features of Big Data, Big Data Value, the Development and Challenges of Big Data,	Classroom Lecture and Discussion	1
2	**Big Data Related Technologies:** Cloud Computing, Relationship between Cloud Computing and Big, IoT, Relationship between IoT and Big Data, Data Center, Hadoop, Relationship between Hadoop, and Big Data.	Classroom Lecture and Discussion	1, 2
3-4	**Hadoop Ecosystem:** Hadoop Distributed File System (HDFS), MapReduce programming model and examples, Introduction to Apache Hive for data warehousing, Introduction to Apache Pig for data flow scripting, Apache HBase for NoSQL database, Apache Spark overview	Classroom Lecture and Discussion	1, 2
5-6	**Data Storage and Management:** Introduction to distributed databases, Apache Cassandra for distributed database management, MongoDB for NoSQL data storage, Data Warehousing and Business Intelligence, Introduction to Apache Flink, Data lakes and their role in Big Data	Classroom Lecture and Discussion	1, 3
7-8	**Data Processing and Analysis:** Apache Spark fundamentals, Spark RDDs (Resilient Distributed Datasets), Spark SQL and Data Frames, Machine Learning with Apache Spark, Introduction to Spark MLlib, Spark Streaming for real-time data processing.	Classroom Lecture and Discussion	2, 3
9-10	**Data Integration and Workflow:** Apache NiFi for data integration, Apache Airflow for workflow management, Introduction to Apache Kafka, Kafka for real-time event streaming, Integration of data pipelines, Data governance and security in Big Data	Classroom Lecture and Discussion	3, 4
11	**Big Data Processing:** Big Data in the cloud (AWS, Azure, GCP), Serverless computing for Big Data, Advanced analytics and visualization, Graph processing with Apache Giraph, Ethical Considerations in Big Data	Classroom Lecture and Discussion	3, 5
12-13	**Deep Learning in Big Data:** Introduction to deep learning architectures (CNNs, RNNs, GANs), Deep learning frameworks for big data (TensorFlow, PyTorch, Keras), Transfer learning and fine-tuning on large datasets	Classroom Lecture and Discussion	3, 4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
14	**Real-time Analytics and Complex Event Processing:** Stream processing architectures, Apache Flink and its applications in real-time analytics, Handling complex events and patterns in streaming data.	Classroom Lecture and Discussion	3, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Chen, M., Mao, S., Zhang, Y., & Leung, V.C.M. (2014). Big Data: Related Technologies, Challenges and Future Prospects, Springer.
ii. Hrushikesha. M., Prachet. B., and Deepak. C., (2015). Big Data: A Primer, Springer.

Supplementary Readings:

i. Zikopoulos, P.C., Eaton, C., Deroos, D., Deutsch, T., & Lapis, G. (2012). Understanding Big Data, McGraw Hill, New York.
ii. Baesens, B. (2014). Analytics in a Big Data World: The Essential Guide to Data Science and its Applications, Wiley.
iii. Li, K. C., Jiang, H., & Zomaya, A. Y. (Eds.). (2017). Big data management and processing. CRC Press.

Optional Courses for Semester 1:

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5111	Longitudinal Data Analysis	Elective	3.0	100

1. Rationale of the Course:

This course is designed to equip students with the necessary skills and knowledge to analyze and interpret data collected over time. Longitudinal data is prevalent in various fields, such as healthcare, social sciences, and economics, and offers insights into changes and trends that cannot be captured by cross-sectional data analysis alone. This course aims to enable them to conduct research and make informed decisions in their respective fields.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of probability theory and its applications. The specific objectives include:

- To develop a comprehensive understanding of longitudinal data, and the relevance of analyzing data over time.
- To introduce students to statistical models and techniques specifically designed for analyzing longitudinal data.
- To equip students with advanced analytical skills required to interpret and draw meaningful conclusions from longitudinal data.
- To provide practical experience in analyzing real-world longitudinal datasets and translating the findings into actionable insights.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to explain the fundamental characteristics of longitudinal data and its significance in various fields.	3	3	3	1	2
2. Students will be able to apply appropriate statistical models to analyze longitudinal data.	3	3	2	3	2
3. Students will be able to perform advanced data analysis techniques, including the assessment of random effects covariance structures and diagnostic checks for model validation.	2	3	3	3	2
4. Students will be able to identify missing data patterns, choose suitable imputation procedures.	1	2	3	3	2
5. Students will be able to analyze real-world longitudinal datasets, interpret the results.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Longitudinal data:** Concepts, examples, objectives of analysis, problems related to one sample and multiple samples, Sources of correlation in longitudinal data, exploring longitudinal data.	Classroom Lecture and Discussion	1
3	**Linear model for longitudinal data:** Introduction, notation, and distributional assumptions, simple descriptive methods of analysis.	Classroom Lecture and Discussion	1
4-5	**ANOVA for longitudinal data:** Fundamental model, one sample model, Sphericity condition; multiple sample models.	Classroom Lecture and Discussion	2
6-7	**Linear mixed effects models:** Introduction, random effects covariance structure, prediction of random effects, residual analysis, and diagnostics.	Classroom Lecture and Discussion	2
8-9	**Extension of GLM for longitudinal data:** Review of generalized linear models, quasi-likelihood, marginal models, random effects models, transition models, comparison between these approaches; the GEE methods, GEE1 and GEE2.	Classroom Lecture and Discussion	3
10	**Generalized Linear Mixed Models (GLMM):** Introduction, estimation procedures: Laplace transformation; Penalized Quasi Likelihood (PQL); Marginal Quazi Likelihood (MQL);	Classroom Lecture and Discussion	3, 5
11	**Numerical integration:** Gaussian quadrature, Adaptive Gaussian quadrature, Monte Carlo Integration; Markov Chain Monte Carlo sampling; comparison between these methods.	Classroom Lecture and Discussion	3, 5
12	**Statistical analysis with missing data:** Missing data, missing data pattern, missing data mechanism, imputation procedures, mean imputation, hot deck imputation.	Classroom Lecture and Discussion	4, 5
13	Estimation of sampling variance in the presence of non-response, likelihood-based estimation, and tests for both complete and incomplete cases,	Classroom Lecture and Discussion	4, 5
14	Regression models with missing covariate values, applications for longitudinal data.	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Verbeke, G. & Molenberghs, G. (2000). Linear Mixed Model for Longitudinal Data, Springer.

Supplementary Readings:

i. Molenberghs, G. & Verbeke, G. (2005). Models for Discrete Longitudinal Data. New York: Springer-Verlag.
ii. Diggle, P.J., Heagerty, P., Liang, K.-Y., & Zeger, S.L. (2002). Analysis of Longitudinal Data, 2nd edition. Oxford.
iii. Faraway, J. J. (2016). Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models. Chapman and Hall/CRC.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5112	Advanced Categorical Data Analysis	Elective	3.0	100

1. Rationale of the Course:

This course aims to provide students with a deeper understanding of complex statistical methods and models tailored for categorical data. Categorical data are prevalent in various fields, including social sciences, healthcare, and marketing research. This course addresses the growing need for professionals who can navigate and effectively analyze categorical data, enabling them to uncover valuable insights and contribute to evidence-based decision-making.

2. Course Objectives:

The course aims to equip students with an in-depth understanding of advanced categorical data analysis techniques. Specific objectives include:

- To enhance students' expertise in analyzing and interpreting categorical data using advanced statistical methodologies.
- To empower students with the capability to apply advanced categorical data analysis techniques to address complex real-world challenges.
- To cultivate students' ability to conduct research and apply advanced categorical data analysis methods.
- To enable students to proficiently perform statistical inference and effectively interpret models.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to understand specialized models, including polytomous logistic regression, conditional logistic regression, ALR, GAM, etc.	3	3	3	1	1
2. Students will be able to apply advanced categorical data analysis to real-world problems, effectively interpret results, and provide practical solutions.	2	3	3	3	2
3. Students will be able to conduct research projects using advanced categorical data analysis, contributing to evidence-based decision-making.	1	1	2	3	3
4. Students will be able to expertly interpret complex models, identify key factors influencing outcomes.	1	2	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Advanced Logistic Regression:** Polytomous logistic regression, Conditional logistic regression, Logistic regression with complex survey data.	Classroom Lecture and Discussion	1
2-3	**Alternating Logistic Regression (ALR):** Brief overview of categorical data. Motivation for using Alternating Logistic Regression. ALR model equation. Parameters estimations and link functions in the ALR framework.	Classroom Lecture and Discussion	1, 3, 4
4-5	**ALR in Longitudinal Data:** Applying ALR to analyze longitudinal ordinal data. Addressing challenges related to repeated measures.	Classroom Lecture and Discussion	1, 3, 4
6-7	**Generalized Additive Model (GAM):** Concept of flexible models. Formulation of the GAM equation. Interpretation of smooth terms and parametric terms. Introduction to various smoothing functions. Choice of smoothing functions.	Classroom Lecture and Discussion	1, 3, 4
8-9	**Latent Class Analysis and Finite Mixture Models:** Latent class models for categorical data clustering, Finite mixture models for heterogeneous populations, Model selection, and assessment of fit.	Classroom Lecture and Discussion	1, 3, 4
10	**Discuss extensions of GEE:** Extensions of GEE such as weighted GEE and robust GEE, marginal models, and model selection strategies.	Classroom Lecture and Discussion	3, 4
11-12	**Multivariate GEE:** Extend GEE to handle multivariate outcomes. Multivariate GEE models.	Classroom Lecture and Discussion	3, 4
13-14	**Bayesian Methods for Categorical Data:** Introduction to Bayesian inference for categorical data, Markov Chain Monte Carlo (MCMC) methods for complex models, and Hierarchical models for multi-level categorical data.	Classroom Lecture and Discussion	2, 4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Agresti, A. (2012). Categorical Data Analysis, 3rd Edition, Wiley.
ii. Agresti, A. (2018). An introduction to categorical data analysis. 3rd Edition, Wiley.

Supplementary Readings:

i. Cameron, A.C., & Trivedi, P.K. (2013). Regression Analysis of Count Data, 2nd Edition, Cambridge University Press.
ii. Long, J. S. (1997). Regression Models for Categorical and Limited Dependent Variables, Sage Publications.
iii. Gelman, A., & Hill, J. (2006). Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press.
iv. Bilder, C. R., & Loughin, T. M. (2014). Analysis of categorical data with R. CRC Press.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5113	Advanced Time Series Analysis	Elective	3.00	100

1. Rationale of the Course:

This course offers a deep dive into critical techniques like Unit Root Analysis, Cointegration Analysis, and Modeling Volatility, with a focus on parametric and nonparametric methods. It emphasizes understanding the limitations and applicability of various tests through comparative studies. The course also explores advanced topics like ARCH/GARCH processes and non-linear time series models, equipping students with comprehensive skills for analyzing and forecasting economic data.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Advanced Time Series Analysis. The specific objectives include:

- To master key concepts and methods in Unit Root Analysis and Cointegration for effective time series data analysis.
- To develop proficiency in applying ARCH/GARCH models to analyze and forecast economic volatility.
- To cultivate critical thinking skills for evaluating and comparing various time series analysis techniques.
- To gain expertise in non-linear time series models to enhance data analysis and forecasting accuracy in economic and financial contexts.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to apply parametric and nonparametric unit root analysis to time series data effectively.	3	3	2	1	2
2. Students will be able to proficiently use cointegration techniques and ARCH/GARCH models for analyzing economic data.	3	3	2	3	2
3. Students will be able to critically evaluate various time series analysis methods.	2	3	3	2	2
4. Students will be able to employ advanced non-linear time series modeling for accurate economic forecasting.	1	2	3	3	2
5. Students will be able to apply theoretical concepts to practical scenarios in economic and financial data analysis.	1	2	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Unit Root Analysis:** Concept of Unit Roots (Parametric and Nonparametric), Dickey-Fuller (DF) Test, Augmented DF Test; DF-GLS (Generalized Least Square) Test.	Classroom Lecture and Discussion	1
2	Nonparametric Unit Root Test, Phillips-Perron tests (PP) Tests: Specification of Hypothesis in Unit Root Test.	Classroom Lecture and Discussion	1
3-4	Tests with Unit Root as Null and Tests with Stationary as Null, Moving average Unit Root Tests, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, Leybourne and McCabe (LM) Test, Confirmatory Analysis of Unit Root Tests.	Classroom Lecture and Discussion	1
5-6	**Comparative Study**: Size Distortion and Low Power of Tests. Different Panel Data Unit Root Tests.	Classroom Lecture and Discussion	1
7	**Cointegration Analysis:** Methods of Estimation of Single Equation: Engle-Granger Methods, System Methods: Triangular System, Johansen Procedure and Common Trends Representation, Identification Problem in Cointegration System.	Classroom Lecture and Discussion	3
9-10	**Cointegration and Granger-Causality:** Concept of Multi-cointegration and Polynomial Integration with Examples, Tests for Cointegration of Single Equation Residual Based Tests, Multiple Equation Methods.	Classroom Lecture and Discussion	3
11	**Modeling Volatility:** Economic Time Series, ARCH Processes, ARCH and GARCH Estimates of Inflation, GARCH Model of PPI: Example, GARCH Model Risk, ARCH-M Model, Additional Properties of GARCH Processes, IGARCH, EGARCH, GARCH-M, QGARCH, GJR-GARCH, TGARCH model, fGARCH, COGARCH, ZD-GARCH, Spatial GARCH model.	Classroom Lecture and Discussion	2, 5
12	Maximum Likelihood Estimation of GARCH Models, Other Models of Conditional Variance, Estimating NYSE Composite Index.	Classroom Lecture and Discussion	2, 5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
13	**Non-Linear Time-Series Models:** Linear Versus Non-Linear Adjustment, Simple Extensions of ARIMA Model, Threshold Autoregressive Models, Extensions and Other Non-Linear Models,	Classroom Lecture and Discussion	4, 5
14	Testing for Non-Linearity, Estimates of Regime Switching Models, Generalized Impulse Responses and Forecasting, Unit Roots, and Non-Linearity.	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1 to CLO-5	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Hamilton, J. D. (1994). Time Series Analysis, Princeton University Press, New Jersey.
ii. Enders, W. (2004). Applied Econometric Time Series, 2nd Edition, John Wiley and Sons (Asia) Pte. Ltd.

Supplementary Readings:

i. Shumway, R. H., Stoffer, D. S., and Stoffer, D. S. (2000). Time series analysis and its applications. New York: Springer.
ii. Box, G. E., Jenkins, G. M., Reinsel, G. C., and Ljung, G. M. (2015). Time series analysis: forecasting and control. 5th Edition, John Wiley & Sons.
iii. Wei, W. W. (2018). Multivariate time series analysis and applications. John Wiley & Sons.
iv. Maddala, G. S. and Kim, I. M. (2008). Unit Roots, Cointegration and Structural Change, Cambridge University Press, Cambridge.
v. Gersch, W. and Kitagawa, G. (1996). Smoothness Priors of Time Series Analysis, Springer, New York.
vi. Gourierousx, C. (1997). ARCH Model and Financial Applications, Springer, New York.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5114	Meta Analysis	Elective	3.00	100

1. Rationale of the Course:

Meta-analysis comprises a powerful tool for synthesizing prior research and empirically validating theoretical frameworks. This course offers an in-depth exploration of its techniques, from basic concepts to advanced topics like heterogeneity, meta-regression, and publication bias. It aims to equip learners with the skills to effectively conduct and interpret meta-analyses, addressing both statistical significance and real-world applications.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Meta Analysis. The specific objectives include:

- To gain a solid understanding of the basic concepts, methodologies, and critical assessments involved in meta-analysis.
- To learn how to analyze different types of data, interpret effect sizes, and choose appropriate models for meta-analysis.
- To delve into more complex aspects such as heterogeneity, meta-regression, and power analysis, and their practical applications in research.
- To develop skills to identify and address common challenges in meta-analysis, such as publication bias and the interpretation of complex data scenarios.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be recognizing the appropriate use of a fixed effects model vs. a random effects model for a meta-analysis.	3	3	3	1	2
2. Students can learn how to describe the rationale for a test of heterogeneity among the studies used in a meta-analysis.	3	3	2	3	2
3. Students can learn how to describe methods for performing a sensitivity analysis of the meta-analysis.	2	3	3	2	3
4. Students should be able to recognize patterns in a ‘funnel plot’.	1	2	3	3	3
5. Students should be able to learn how publication bias can affect the results of a systematic review.	1	1	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Introduction**: Concept of Meta-Analysis. Strengths, Weaknesses, Criticisms of Meta-Analysis, Statistical Significance, Clinical Importance of Effect, Consistency of Effects.	Classroom Lecture and Discussion	1
2	**Effect Size and Precision:** Treatment Effects and Effect Sizes, Effect Sizes Based on: Binary Data (2×2 Tables) and Correlations, converting among Effect Sizes, Factors that affect Precision, Relationship between Effect Size and P values.	Classroom Lecture and Discussion	1
3-4	**Fixed Effect Model and Random Effect Model:** Fixed-Effect vs. Random-Effects Models.	Classroom Lecture and Discussion	1
5-6	**Heterogeneity:** Identifying and Quantifying Heterogeneity, Prediction Intervals, Subgroup Analyses,	Classroom Lecture and Discussion	2
7-9	Sub-Group Analysis: Meta-Regression: Explanation of meta-regression as an extension of meta-analysis. Purpose and benefits of using meta-regression. Formulating a Meta-Regression Model, Selecting potential predictors in meta-regression.	Classroom Lecture and Discussion	2, 3
10-11	**Power Analysis for Meta-Analysis:** When to use Power Analysis, Planning for Precision rather than for Power, Power Analysis in Primary Studies and Meta-Analysis, power Analysis for a Test of Homogeneity.	Classroom Lecture and Discussion	2, 3
12	**Publication Bias**: Introduction, problem of missing studies, methods for addressing bias, some important caveats, Small-study effects, Funnel plot, Patterns in funnel plot, Narrative reviews vs. meta-analyses.	Classroom Lecture and Discussion	4, 5
13	**SIMPSON'S Paradox**: Overview, relationship between Circumcision and HIV Infection Risk, Case studies Illustrating the Paradox	Classroom Lecture and Discussion	4, 5
14	**Psychometric Meta-Analysis:** The Attenuating Effects of Artifacts, Meta-Analysis Methods, Example of Psychometric Meta-Analysis.	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Borenstein, M., Hedges, L.V., Higgins, J.P.T., & Rothstein, H.R. (2021). Introduction to Meta-Analysis, 2nd Edition, Wiley.

ii. Harrer, M., Cuijpers, P., Furukawa, T., & Ebert, D. (2021). Doing meta-analysis with R: A hands-on guide. Chapman and Hall/CRC.

Supplementary Readings:

i. Harris, M.C. (2016). Research Synthesis and Meta-Analysis: A Step-By-Step Approach (Applied Social Research Methods), 5th Edition, Sage Publications, Inc.

ii. Mark, W.L. & David, W. (2000). Practical Meta-Analysis (Applied Social Research Methods), 1st Edition, Sage Publications, Inc.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5115	Spatial Data Analysis	Elective	**Value:** 3.0	100

1. Rationale of the Course:

Spatial data analysis is a broad field. This course is considered as a core infrastructure of modern IT world, which is substantiated by business transactions of major IT companies such as Apple, Google, Microsoft, Amazon, Intel, and Uber, and even motor companies such as Audi, BMW, and Mercedes. Additionally, this course could make learners realize the importance of spatial big data to deal with real world data science problems.

2. Course Objectives:

The overall goal of this course is to learn appropriate tools for spatial data analysis. The specific objectives are for the students to:

- To understand spatial epidemiology and the properties of various spatial data types.
- To develop skills in visualizing and standardizing spatial data.
- To gain insights into spatial autocorrelation indicators and basic modeling techniques.
- To explore advanced Bayesian methods for complex spatial data applications.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will comprehend key concepts in spatial epidemiology and different types of spatial data.	3	2	2	1	2
2. Students will acquire skills in mapping and standardizing spatial data and creating choropleth maps.	3	3	2	3	2
3. Students will learn to identify and analyze spatial autocorrelation using appropriate indicators and models.	2	3	3	2	2
4. Students will gain proficiency in applying Bayesian methods to spatial data problems.	1	2	3	3	2
5. Students will demonstrate the ability to apply spatial data analysis methods in real-world scenarios like disease mapping.	1	2	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Basic Concept:** Introduction, spatial epidemiology, properties and nature of spatial data and spatial process, Classes of spatial data, Geostatistical data, lattice data, spatial point process.	Classroom Lecture and Discussion	1
3	**Exploring Areal Unit data:** Mapping count data, LIKAR data, issues with crude counts, making rates comparable (standardization).	Classroom Lecture and Discussion	1, 2

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
4-5	Making choropleth map, classification of schemes, class number and colours, defining the Neighbourhood structure, spatial weights.	Classroom Lecture and Discussion	2
6-7	**Spatial Autocorrelation:** definition, global indicators of spatial autocorrelation, Moran' I, Geary's c, local indicators of spatial autocorrelation (LISA).	Classroom Lecture and Discussion	3
8-9	Modelling Areal unit data-Aggregate count data, traditional models, and methods, spatial smoother.	Classroom Lecture	2,3
10-12	**Hierarchical Bayesian Methods:** Poisson-Gamma model, Poisson-Lognormal model, Conditional autoregressive (CAR) model, proper CAR model, convolution model, Bayesian specification of CAR model, MCMC computation, other correlation models.	Classroom Lecture and Discussion	3, 4, 5
13-14	**Bayesian Spatial Data Analysis:** Binomial model, spatial epidemiological issues, count data models, disease mapping, Risk estimation, disease clustering, ecological analysis, image analysis, fMRI modelling.	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1 to CLO-5	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Moraga, P. (2023). Spatial Statistics for Data Science: Theory and Practice with R. CRC Press.
ii. Blangiardo, M., & Cameletti, M. (2015). Spatial and spatio-temporal Bayesian models with R-INLA. John Wiley & Sons.

Supplementary Readings:

i. Haining, R. P., & Li, G. (2020). Regression Modelling Wih Spatial and Spatial-Temporal Data: A Bayesian Approach. CRC Press.
ii. Kopczewska, K. (2020). Applied spatial statistics and econometrics: data analysis in R. Routledge.
iii. Waller, L.A. & Gotway, C.A. (2004). Applied Spatial Statistics for Public Health Data, John Wiley and Sons Inc., New York.
iv. Lesaffre, E. & Lawson, A.B. (2012). Bayesian Biostatistics, John Wiley and Sons Inc., New York.
v. Schabenberger, O., & Pierce, F.J. (2001). Contemporary Statistical Models for the Plant and Soil Sciences, CRC Press, New York.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0610-5116	Computer Intensive Statistics	Elective	**Value:** 3.0	100

1. Rationale of the Course:

The course is designed to equip students with the essential skills to navigate the complexities of contemporary statistical analysis. By integrating computational approaches into statistical methodologies, students will be better prepared to tackle real-world challenges, make informed decisions, and contribute meaningfully to the evolving field of statistics in the era of big data.

2. Course Objectives:

The overall goal of this course is to discuss highly computational statistics relating to the computer. The specific objectives are for students to:

- To learn bias correction, pseudo-value calculation, and extending jackknifing to multiple sample problems.
- To understand bootstrapping strategies, sampling distributions, and bootstrap distributions.
- To grasp the use of confidence limits in percentile bootstrap, its application in hypothesis testing, and its variants.
- To acquire knowledge in simulation testing methods and fundamentals of density estimation.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will learn to apply jackknifing techniques for bias correction and multi-sample analysis.	3	2	2	1	2
2. Students will understand basic bootstrapping strategies and distribution analysis.	3	3	2	3	2
3. Students will master using percentile bootstrap for hypothesis testing and its computational aspects.	2	3	3	2	2
4. Students will develop skills in various simulation testing methods and their practical applications.	2	2	3	3	2
5. Students will gain knowledge in kernel selection and smoothing parameter choices for effective density estimation.	3	2	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Jackknifing:** Bias Correction, Pseudo-Value, Approximate Confidence Intervals, Extension to 2-or-More-Sample Problems.	Classroom Lecture and Discussion	1
2	**Bootstrapping:** Bootstrap Strategy, Sampling Distributions, Empirical Distributions, Bootstrap Distributions.	Classroom Lecture	2
3-4	**Percentile Bootstrap:** Definition and use of Confidence Limits, Relation to Jackknife, Application to Hypothesis Testing, Number of Simulation Samples Required, Variants: Smoothed	Classroom Lecture and Discussion	3

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
	Bootstrap, Bias-Corrected Bootstrap, Computational Aspects, Balanced Re-Sampling.		
5-6	**Simulation Testing:** Randomization Test, Approximate Randomization Test, Monte-Carlo Tests. Unbiasedness, Power, Number of Simulated Samples Needed.	Classroom Lecture and Discussion	4
8-9	**Density Estimation:** Definition, Examples, Bias, MSE and IMSE, Choice of Kernel, and Smoothing Parameter, Computation Via Fast Fourier Transform,	Classroom Lecture and Discussion	5
10-11	Different methods of Kernel estimation, shape-adjusted method for Kernel estimation, Kernel Estimation in Nonparametric Regression.	Classroom Lecture and Discussion	5
12-14	**Semiparametric and Nonparametric Regression:** local polynomial fitting, estimation of conditional mean function, quantile regression, semiparametric quantile estimation.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1 to CLO-5	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Zwanzig, S., & Mahjani, B. (2019). Computer Intensive Methods in Statistics. Chapman and Hall/CRC.
ii. Eforn, B. and Tibshirani, R. J. (1993). An Introduction to Bootstrap, Chapman and Hall, New York.
iii. Efron, B. (1987). The Jackknife, the Bootstrap and other Re-Sampling Plans, Society for Industrial Mathematics.

Supplementary Readings:

i. Hjorth, J. U. (2017). Computer intensive statistical methods: Validation, model selection, and bootstrap. Chapman and Hall/CRC.
ii. Chernick, M. R., & LaBudde, R. A. (2014). An introduction to bootstrap methods with applications to R. John Wiley & Sons.
iii. Noreen, E. W. (1989). Computer-Intensive Methods for Testing Hypothesis, Wiley, New York.
iv. Shao, J. and Tu, D. (1995). Jackknife and Bootstraps, Springer-Verlag, New York.
v. Silverman, B. W. (1986). Density Estimation for Statistics and Data Analysis, Chapman and Hall, London.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5117	Bioinformatics and Genetic Algorithm	Elective	3.0	100

1. Rationale of the Course:

This course is designed to introduce the computational and algorithmic challenges in biological data analysis. Students will gain exposure to advanced statistical and computational methods, enhancing their skills in Bio-Analytics, Data Analytics, Proteomics, and Information Technology. They will learn to apply these methodologies in various fields such as Pharmacology, utilizing bioinformatics tools to manage and analyze large-scale biological data effectively.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Bioinformatics and Genetics with the application of Statistics. The specific objectives include:

- To grasp the basics of biology, formal and molecular genetics, and inheritance patterns
- To acquire knowledge in genetic markers, genotyping, Hardy-Weinberg Equilibrium, and quality control techniques for genotype data.
- To develop skills in genetic association analysis, study design, and understanding linkage disequilibrium.
- To gain proficiency in using primary and secondary biological databases, sequence alignment techniques, and bioinformatics software for data analysis.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will understand key concepts in biology, genetics, and inheritance.	3	2	2	1	2
2. Students will learn to identify genetic markers and perform genotype data quality control.	3	3	2	3	2
3. Students will develop skills in genetic association and linkage analysis.	2	3	3	2	2
4. Students will gain proficiency in using biological databases and file formats.	1	2	3	3	2
5. Students will acquire the ability to apply bioinformatics tools for data analysis.	3	2	2	1	2

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Fundamentals of Biology:** Basic Biology, Formal and Molecular Genetics, Inheritance Pattern.	Classroom Lecture and Discussion	1
3-4	**Genetic Markers and Quality Control:** Genetic Markers, Genotyping, HWE; Quality control (QC) for genotype data.	Classroom Lecture and Discussion	2
5	**Genetic Association and Linkage Analysis:** Genetic Association Analysis, Study design; Linkage disequilibrium (LD).	Classroom Lecture and Discussion	3
6-7	**Biological Databases and File Formats:** Primary databases (DDBJ, GenBank, EMBL), Secondary databases (HapMap, 1000 Genomes Project) Genome Databases (Ensembl, NCBI etc.) Protein sequence databases (DisProt, Swiss-Prot etc.) Protein structure database, Protein expression database, Specialized databases (TCGA).	Classroom Lecture and Discussion	4
8-9	**Genome-wide Association Studies (GWAS):** Genotype imputation, Statistical analysis for GWAS, Replication of the results from GWAS, Meta-analysis of GWAS; Clinical impact of GWAS.	Classroom Lecture and Discussion	4
10	**Genetic Association and Linkage Analysis:** Pairwise and Multiple Sequence Alignment, Sequence-based database search algorithm.	Classroom Lecture and Discussion	4
11-12	**Statistical and Machine Learning Approaches**: Support Vector Machine; Artificial neural network, Deep learning, Hidden Markov chain.	Classroom Lecture and Discussion	5
13-14	**Bioinformatics Analysis Tools:** Analysis toolsets (software) for analyzing massive amount of biological data.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Ziegler, A., Konig, I. R., & Pahlke, F. (2012). A Statistical Approach to Genetic Epidemiology: Concepts and Applications, with an E-learning platform, 2nd Edition, Wiley-Blackwell.
ii. Foulkes, A., S., (2009). Applied Statistical Genetics with R: For Population-based Association Studies, Springer.

Supplementary Readings:

i. Mills, M. C., Barban, N., & Tropf, F. C. (2020). An introduction to statistical genetic data analysis. Mit Press.
ii. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P., (2014). Essential Cell Biology, 4th Edition, Taylor & Francis Group, New York.
iii. Warren Ewens and Gregory Grant, (2005). Statistical Methods in Bioinformatics: An Introduction, 2nd Edition, Springer.
iv. Lesk, A., (2014). Introduction to Bioinformatics, 4th Edition, Oxford University Press.
v. Baxevanis, A. D., and B. F. Ouellette, (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, John Wiley and Sons.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0314-5118	Advanced Demography and Population Studies	Elective	3.00	100

1. Rationale of the Course:

This course is essential for understanding complex population dynamics and their implications on global challenges such as urbanization, public health, and environmental sustainability. It equips students with advanced analytical skills to interpret demographic data and trends, vital for informed decision-making in fields like public policy, economics, and public health.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Applied Demography and Population Studies. The specific objectives include:

- To gain a comprehensive understanding of key demographic concepts including nuptiality, reproductive age, and family planning.
- To develop skills to analyze and interpret data related to mortality, fertility, migration, and urbanization.
- To learn to apply various demographic models and methods, such as stable population models and population projections, to real-world scenarios.
- To understand the social and policy implications of demographic trends, focusing on issues like gender-based violence and population aging.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to analyze marriage rates and patterns, including age-specific trends and average ages at marriage.	3	2	2	1	2
2. Students will gain skills in evaluating family planning methods and their effectiveness, including contraceptive use analysis.	3	3	2	3	2
3. Students will learn to apply demographic models to estimate mortality and fertility rates from various data sources.	2	3	3	2	2
4. Students will develop an understanding of migration types, trends, and their impact on urbanization.	1	2	3	3	2
5. Students will be able to apply demographic knowledge to address global challenges such as population aging and gender-based violence.	2	2	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Nuptiality:** Concept, Nuptiality Rates: Crude Marriage Rate, Age-specific Marriage Rates, Mean Age at Marriage, Singulate Mean Age at Marriage. Nuptiality models, Nuptiality table, Nuptiality pattern in Bangladesh.	Classroom Lecture and Discussion	1
2	**Reproductive Age, Family Planning Methods & Couple Year Protection:** Basic Concepts and Definitions, Overview of Family Planning Methods, Calculation of Couple Year Protection.	Classroom Lecture and Discussion	1
3	**Effectiveness of Contraceptive Use:** Fecundability and Fecundity, Life Table Analysis of Contraceptive Failure, Construction of Single and Multiple Decrement Life Table.	Classroom Lecture and Discussion	2
4-6	**Mortality and Fertility models:** Birth Averted by Family Planning program. Bongaarts model and proximate determinants, targeting and Projection by Bongaarts Model. Estimation of Adult Mortality by Indirect Means (Such as Orphan Hood, Widowhood methods), Gompertz Model, Reduced Gompertz Model. Estimation of fertility and Mortality from two censuses, age Distribution, Estimation of Mortality from Census based method, census coverage and Estimation, completeness of Coverage of Census and Vital Registration Data.	Classroom Lecture and Discussion	3
7	**Gender Preference:** Family Size, Ideal Family Size, Sex Preference of Family Size, Factors Affecting Sex Preference in Bangladesh, Relationship Between Actual Fertility and Ideal Fertility, Fertility of Spacers and Limiters and their Effect. Effect of under Five Mortality or Infant Mortality on Desired Family Size.	Classroom Lecture and Discussion	2,3
8	**Migration and Urbanization:** Concepts of Migration, Types and Measures of Migration, Consequences, Determinant's and Trends of Migration. Urbanization and Measures of Urbanization.	Classroom Lecture and Discussion	4
9	**Stable Population Model:** Stable, quasi-stable and stationary population model. Fertility, mortality, and age structure in stable population. Lotka and Dublen's model.	Classroom Lecture and Discussion	3
10-11	**Population Projection & Forecasting:** Population estimates and projections. Mathematical methods, Component method of population projection. Markov Chains for Individual life histories. Features of forecasting and forecasting error.	Classroom Lecture and Discussion	4, 5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
12	**Population Aging:** Elderly Situation, Aging Index, Support Ratio Index, Care Index, Elderly Situation in Bangladesh, Goals and Components (Elements) of Aging Policy in Bangladesh.	Classroom Lecture and Discussion	5
13	**Gender Based Violence (GBV):** Concept, Reasons for GBV, Measures of GBV: Physical, Sexual, Emotional, Economic and Controlling Behaviour. Domestic Violence, Socio- Economic and Reproductive Health Implication of GBV. Steps in Reducing Gender Based Domestic Violence.	Classroom Lecture and Discussion	5
14	**Other Issues in Demography:** Social Development Indicators. Advocacy, Components of Advocacy. Social and Behavioural Change (SBC) strategies. **Sustainable Development Goal (SDG):** Rational and Motivation Behind SDG, Goal, Target, Indicator of SDG, Current Situation of Bangladesh Considering Different Indicators.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Chiang, C. L. (1984). The Life Table and its Applications, Krueger Pule, John Wiley, New York.
ii. Bongaarts, J. and, Potter, R. G. (1983). Fertility, Biology and Behaviour: An Analysis of the Proximate Determinants of Fertility, Academic Press, Sandiego, California.

Supplementary Readings:

i. Colin, N. (1988). Methods and Models in Demography, Belhaven Press, London.
ii. Selected Articles from Population Studies, Demography, Population and Development Studies in Family Planning etc.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks: 100
0532-5119	Remote Sensing and GIS	Elective	3.0	

1. Rationale of the Course:

This course is designed to introduce the principles and applications of remote sensing and Geographic Information Systems (GIS). Students will learn the fundamentals of remote sensing technology, data acquisition, image interpretation, and GIS data management. Practical applications in environmental science, urban planning, and natural resource management would be explored.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Remote Sensing and GIS and its applications. The specific objectives of this course included:

- To gain a deep understanding of the fundamental principles underlying remote sensing and the technical aspects and limitations.
- To perform critical evaluations of digital image processing techniques, spanning from data preprocessing to image classification.
- To employ digital image processing to extract geographical information from remotely sensed data.
- To learn how to integrate remote sensing data and GIS for comprehensive geospatial analysis and decision-making.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will understand the fundamental principles of remote sensing.	3	3	2	1	2
2. Students will be able to design, implement, and critically evaluate a range of digital image processing techniques, and conduct field data collection, and accuracy assessment.	2	3	2	3	2
3. Students should be capable of utilizing digital image processing to extract geographic information from remotely sensed data.	2	3	3	2	2
4. Students should be able to evaluate the opportunities and methods for integrating remote sensing and GIS for comprehensive geospatial analysis and decision-making.	1	2	3	3	2
5. Students should develop the skill to understand the principles of GIS data management and its application in various domains.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Introduction to Remote Sensing:** Overview of Remote Sensing, Electromagnetic Spectrum and Sensors, Data Acquisition Methods, Limitations and Constraints	Classroom Lecture and Discussion	1
3-4	**Digital Image Processing Techniques:** Data Preprocessing, Image Enhancement, Image Classification, Field Data Collection, Accuracy Assessment	Classroom Lecture and Discussion	2
5-6	**Geographic Information Systems (GIS) Fundamentals:** Introduction to GIS, Spatial Data Models, Coordinate Systems and Map Projections, Data Sources for GIS	Classroom Lecture and Discussion	3, 4
7-8	**Data Collection and Integration:** GPS and Data Collection Tools, Data Accuracy and Precision, Field Surveys and Mobile GIS, Data Editing and Quality Control	Classroom Lecture and Discussion	2, 3
9-10	**Spatial Analysis in GIS:** Spatial Query and Analysis, Overlay Operations, Network Analysis, Terrain Analysis	Classroom Lecture and Discussion	4
11-12	**Environmental Applications:** Land Use/Land Cover Mapping, Environmental Monitoring, Environmental Impact Assessment, Case Studies	Classroom Lecture and Discussion	4, 5
13-14	**Urban Planning and Natural Resource Management:** GIS in Urban Planning, Location-Based Services (LBS), Natural Resource Management, Case Studies	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lectures, Practical Exercises, in GIS Software, Interactive Group Discussion, field data collection, case studies, and project work.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Burrough, P. A., McDonnell, R. A. and Lloyd, C, (2015). Principles of Geographical Information Systems, 3rd Edition. Oxford University Press.
ii. Campbell, J.B., (2022). Introduction to Remote Sensing, 6th Edition. New York, Guilford Press.
iii. Bhatta, B. (2021). Remote sensing and GIS, 3rd Edition, Oxford University Press.

Supplementary Readings:

i. Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (2015). Geographic Information Systems and Science, 4th Edition. Wiley.
ii. Krygier, J. and Wood, D., (2016). Making maps – A visual guide to map design for GIS, 3rd Edition. The Guilford Press.
iii. Lawhead, J. (2023). Learning geospatial analysis with Python. 4th Edition, Packt Publishing Ltd.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0521-5120	Environmental Statistics and Modeling	Elective	3.00	100

1. Rationale of the Course:

This course is designed to equip students with the specialized analytical tools and techniques essential for addressing complex environmental challenges. This course aims to bridge the gap between theoretical statistical concepts and practical applications in environmental science, empowering students to make informed decisions in environmental research and policymaking. Through hands-on exercises and case studies, participants will gain the skills necessary to navigate intricate environmental datasets in the context of environmental issues.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Environmental Statistics and its applications. The specific objectives include:

- To equip students with advanced statistical tools and techniques specifically tailored for analyzing environmental data.
- To enhance students' ability to interpret complex environmental data sets critically.
- To learn to apply statistical methods to address real-world environmental challenges.
- To produce professionals who can bridge the gap between statistical expertise and environmental research, facilitating the integration of statistical methodologies.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will gain a basic understanding of statistical methods in Environmental analysis.	3	3	3	1	2
2. Students can develop skills in modeling environmental data and to interpret the results of statistical models in the context of environmental processes.	2	3	2	3	2
3. Students can gain expertise in spatial and temporal statistical analysis methods relevant to environmental studies.	2	3	3	2	2
4. Students should be able to apply geostatistical and spatiotemporal techniques to investigate patterns, trends, and variability in environmental data.	1	3	3	3	2

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Environmental Monitoring and Sampling:** Inaccessible and Sensitive Data, Encountered Data, Length-Biased or Size-Biased Sampling and Weighted Distributions, Ranked-Set Sampling. Quadrat Sampling, Transect Sampling and Adaptive Sampling.	Classroom Lecture and Discussion	1
3	**Outliers and Robustness:** Outlier and Robustness, Aims and Objectives of Outlier, Importance of Outliers in Environmental Studies, Outlier-Generated Models, Multiple Outliers: Masking and Swamping. Accommodation: Outlier-Robust Methods, Multivariate Outliers, Detecting Multivariate Outliers. Tests of Discordancy, Robustness in General.	Classroom Lecture and Discussion	1
4	**Environmental Standards:** Concept of Environmental Standards, Statistically Verifiable Ideal Standard (SVIS), Guard Point Standards, Standards along Cause-Effect Chain.	Classroom Lecture and Discussion	1, 2
5-6	**Environmental Modelling and Applications:** Applications of Modelling in Environmental Data Analysis. Numerical Analysis and Modeling, Time Series Modelling. Generalized Linear Mixed Model.	Classroom Lecture and Discussion	4
7-8	**Spatial and Temporal Modeling in Environmental Statistics:** Spatial statistics for environmental data, Temporal analysis and time series modeling. Geostatistics and its applications in environmental studies. Advanced techniques for analyzing spatiotemporal data in the environmental context.	Classroom Lecture and Discussion	2, 3
9	**Bayesian Statistics in Environmental Research:** Introduction to Bayesian statistics, Bayesian inference in environmental modeling.	Classroom Lecture and Discussion	3, 4
10	**Spatial Prediction and Kriging:** Ordinary Kriging, Effect of Variogram Parameters on Kriging, Lognormal and Trans-Gausian Kriging, Cokriging, Robust Kriging, Universal Kriging, Median-Polish Kriging.	Classroom Lecture and Discussion	2, 4
11	**Extreme Value Distributions:** Concept of extremes in Environment. Extreme Value distribution, Limiting distribution of Extreme value distribution. Generalized Extreme Value (GEV) Distributions.	Classroom Lecture and Discussion	2, 4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
12-13	**Modeling of Natural Hazards:** Heavy rainfall, peak river flows, heat waves, extreme sea surface temperatures, strong wind gusts, extreme wave heights, high pollution levels, devastating landslides, dangerous wildfires.	Classroom Lecture and Discussion	4
14	**Climate Change Modelling:** IPCC Scenarios. Global Circulation Model (GCM), Regional Climate Model (RCM).	Classroom Lecture and Discussion	2, 4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examinations.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Clark, M. M. (2009). Transport Modeling for Environmental Engineers and Scientists, 2nd Edition, Wiley.
ii. Schnoor, J. L. (1996). Environmental Modeling: Fate and Transport of Pollutants in Water, Air and Soil, John Wiley & Sons, Inc., New York, USA.
iii. Wayne, R. Ott (1995). Environmental Statistics and Data Analysis, Lewis Publishers, England.

Supplementary Readings:

i. Barnett, V. (2004). Environmental Statistics: Methods and Applications, John Wiley and Sons, New York.
ii. Kotz, S., & Nadarajah, S. (2000). Extreme value distributions: theory and applications. world scientific.
iii. Harris, M. J. (2002). Environmental and Natural Resource Economics: A Contemporary Approach, Houghton Mifflin Company.
iv. Robert, H. (1990). Spatial Data Analysis in the Social and Environmental Sciences, Cambridge University Press, Cambridge.

LAB/Practical Courses for Semester 1

Course Code:	Course Title:	Course	Credit	Total Marks:
0542-5121	LAB Advanced Multivariate Analysis	**Type:** LAB	**Value:** 1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5101: Advanced Multivariate Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct advanced multivariate analyses.	1	2	1	3	3
2. Students should be able to apply advanced multivariate analysis techniques to real-world problems and make scientific reports.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5101: Advanced Multivariate Analysis".	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5122	LAB- Big Data Analytics	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5102: Big Data" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Big Data analysis.	1	2	1	3	3
2. Students should be able to apply Big Data techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5102: Big Data".	Lab Exercises, Computer intensive learning, Interactive Workshops, H ands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5123	LAB- Longitudinal Data Analysis	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5111: Longitudinal Data Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Longitudinal Data analysis.	1	2	1	3	3
2. Students should be able to apply Longitudinal Data Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5111: Longitudinal Data Analysis".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course	Credit	Total
0542-5124	LAB Advanced Categorical Data Analysis	**Type:** LAB	**Value:** 1.0	**Marks:** 100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5112: Advanced Categorical Data Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Advanced Categorical Data Analysis.	1	2	1	3	3
2. Students should be able to apply Advanced Categorical Data Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5112: Advanced Categorical Data Analysis".	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course	Credit	Total Marks:
0542-5125	LAB- Advanced Time-series Analysis	**Type:** LAB	**Value:** 1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5113: Advanced Time-series Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Advanced Time-series Analysis.	1	2	1	3	3
2. Students should be able to apply Advanced Time-series Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5113: Advanced Time-series Analysis"	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5126	LAB- Meta Analysis	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5114: Meta Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Meta Analysis.	1	2	1	3	3
2. Students should be able to apply Meta Analysis to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5114: Meta Analysis".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5127	LAB- Spatial Data Analysis	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5115: Spatial Data Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Spatial Data Analysis.	1	2	1	3	3
2. Students should be able to apply Spatial Data Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5115: Spatial Data Analysis".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2,3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5128	LAB- Computer Intensive Statistics	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0610-5116: Computer Intensive Statistics" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course, Computer Intensive Statistics.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Computer Intensive Statistics	1	2	1	3	3
2. Students should be able to apply Computer Intensive Statistics techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0610-5116: Computer Intensive Statistics".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5129	LAB- Bioinformatics and Genetic Algorithm	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course “0610-5117: Bioinformatics and Genetic Algorithm" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Bioinformatics and Genetic Algorithm analysis.	1	2	1	3	3
2. Students should be able to apply Bioinformatics and Genetic Algorithm techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course “0610-5117: Bioinformatics and Genetic Algorithm”.	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0314-5130	LAB- Advanced Demography and Population Studies	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0314-5118: Advanced Demography and Population Studies" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Population Studies analysis.	1	2	1	3	3
2. Students should be able to apply Demographic techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0314-5118: Advanced Demography and Population Studies"	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0532-5131	LAB- Remote Sensing and GIS	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0532-5119: Remote Sensing and GIS" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course, Remote Sensing and GIS.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Remote Sensing and GIS analysis.	1	2	1	3	3
2. Students should be able to apply Remote Sensing and GIS techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0532-5119: Remote Sensing and GIS".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0521-5132	LAB- Environmental Statistics and Modeling	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0521-5120: Environmental Statistics and Modeling" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Environmental Statistics and Modeling analysis.	1	2	1	3	3
2. Students should be able to apply Environmental Statistics and Modeling to real-world research.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0521-5120: Environmental Statistics and Modeling".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Computer intensive learning, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Year 5, Semester 2

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5201	Advanced Classical and Bayesian Inference	Core	**Value:** 3.0	100

1. Rationale of the Course:

This course is vital in a world where data-driven decision-making is increasingly prevalent across various fields. This course provides a deep dive into the principles and methodologies of both classical (frequentist) and Bayesian statistical inferences, which are cornerstone approaches in statistical analysis.

2. Course Objectives:

This course is primarily designed to provide students with the fundamentals of advanced classical and Bayesian inference. The specific objectives include:

- To gain a thorough understanding of both classical and Bayesian statistical methods.
- To develop advanced skills in data analysis, focusing on robust statistics and hypothesis testing.
- To acquire expertise in Bayesian modeling, including hierarchical and mixed models.
- To apply statistical theories and methods effectively in real-world data analysis scenarios.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to apply robust statistical methods, including various estimators in diverse data analysis scenarios.	3	3	2	1	2
2. Students will acquire the skills to conduct advanced hypothesis testing.	3	3	2	3	2
3. Students will gain expertise in Bayesian statistical modeling, including the development and application of hierarchical models and mixed models.	2	3	3	2	2
4. Students will demonstrate the ability to apply both classical and Bayesian statistical methods in the analysis and interpretation of real-world data, ensuring informed decision-making in various contexts.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs.

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Robust Statistics**: Concept of Robust Statistics, Influence Functions, Classes of M-Estimators, L-Estimators, R-Estimators, Multidimensional Estimators, Application of Robust Estimators.	Classroom Lecture and Discussion	1
2	U-and V Statistics and their Properties, Best Unbiased Estimators and their Properties.	Classroom Lecture and Discussion	1
3	**Confidence Sets:** Confidence Belt, Randomized Confidence Sets, Invariant Confidence Sets, Bonferroni's Method, Scheffe's Method in Linear Models. Confidence Bands for Cumulative Distribution Functions.	Classroom Lecture and Discussion	2
4	**Bootstrap Confidence Sets:** Construction of Bootstrap Confidence Intervals, Asymptotic and Accuracy, High-Order Accurate Bootstrap Confidence Sets.	Classroom Lecture and Discussion	2
5	**Empirical Processes:** Weak convergence and stochastic equicontinuity, stochastic equicontinuity via summarization and bracketing, Brownian motion and Brownian bridges, Gaussian Processes, Glivenko-Cantelli and Donsker theorems.	Classroom Lecture and Discussion	2
6-7	**Theory of Hypothesis Testing:** Tests Under Restricted Alternatives, Similar Region and Neyman Structure, Most Powerful Similar Region (MPSR) Test, Uniformly Most Powerful Similar Region (UMPSR) Test, Asymptotic Efficiency of Test, Sequential Probability Ratio Test (SPRT) for three Hypotheses,	Classroom Lecture and Discussion	2
8	**Bayesian Tools for Statistical Modeling:** Markov Chain Monte Carlo (MCMC) Algorithm, Hierarchical models, the Poisson-gamma hierarchical model, posterior predictive distributions, Bayesian, and empirical Bayesian approach,	Classroom Lecture and Discussion	3
9	Gaussian hierarchical models, mixed models, the linear mixed model, the generalized linear mixed model, nonlinear mixed models,	Classroom Lecture and Discussion	2, 3
10-11	Estimation of the random effects and posterior predictive distributions, choice of the level-2 variance prior, propriety of the posterior, assessing and accelerating convergence, comparison of Bayesian and frequentist hierarchical models.	Classroom Lecture and Discussion	2, 3
12	**Model building and assessment:** Measures for model selection, the Bayes factor, information theoretic measures for model selection.	Classroom Lecture and Discussion	3, 4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
13	Model selection based on predictive loss functions, model checking, sensitivity analysis, posterior predictive checks.	Classroom Lecture and Discussion	2, 3, 4
14	**Variable selection:** classical variable selection vs Bayesian variable section, variable selection based on Zellner's g-prior, variable section based on Reversible Jump Markov chain Monte Carlo, spike and slab priors, stochastic search variable selection, Gibbs variable selection, Bayesian model selection, Bayesian model averaging.	Classroom Lecture and Discussion	2, 3, 4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. George, C. and Berger, R. L. (2002): Statistical Inference, 2nd Edition, Thompson-Duxbury, USA.
ii. Lehman, E. L. (1997): Testing Statistical Hypothesis, 2nd Edition, Springer-Verlag, New York.
iii. Lesaffre, E.and Lawson, A. B. (2014): Bayesian Biostatistics, John Wiley and Sons Inc., New York.
iv. Gelman, A., Carlin, J. B., Stern, H. S., & Rubin, D. B. (2013). Bayesian data analysis. 3rd Edition, Chapman and Hall/CRC.

Supplementary Readings:

i. Lehman, E. and Cassela, G. (1998): Theory of Point Estimation, 2nd Edition, Springer Verlag, New York.
ii. Hogg, R. H., Mckean, J. W. And Craig, A. T. (2019): Introduction to Mathematical Statistics, 8th Edition, Pearson Education (Singapore) Pte Ltd.
iii. Rohatgi, U. K. and Saleh, A. K. Md. E. (2015): An Introduction to the Probability and Statistics, 3rd Editions, John Wiley and Sons Inc., New York.

Course Code:	Course Title:	Course Type:	Credit Value: 3.0	Total Marks:
0610-5202	Deep Learning	Elective		**100**

1. Rationale of the Course:

This course is designed to offer a thorough initiation into the realm of deep learning, a specialized domain within machine learning that revolves around intricate neural networks featuring multiple layers. This course will cover the fundamental concepts, techniques, and applications of deep learning, enabling students with the knowledge and skills necessary to grasp and effectively employ this influential technology across diverse domains.

2. Course Objectives:

This course is primarily designed to provide students with the fundamentals of deep learning and its applications. The specific objectives include:

- To articulate the fundamental principles and concepts of deep learning.
- To implement deep learning models using widely used frameworks.
- To understand the backpropagation algorithm and gradient descent optimization techniques.
- To demonstrate the ability to train and evaluate deep neural networks for a wide range of applications, and advanced deep learning topics.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will demonstrate a comprehensive understanding of the fundamental concepts and principles of deep learning.	3	2	2	1	2
2. Students will utilize popular deep learning frameworks such as to implement deep neural network models effectively and efficiently.	3	3	2	3	2
3. Students will explain the backpropagation algorithm and apply various gradient descent optimization techniques to train deep learning models.	2	3	3	2	3
4. Students will develop the ability to train, evaluate, and fine-tune deep neural networks for diverse real-world tasks.	1	2	3	3	3
5. Students will explore and analyze advanced deep learning concepts and apply them to solve complex problems in various domains.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Overview of Deep Learning and its Applications:** Feature extraction, Image classification, object detection, speech recognition, text recognition, fraud detection, etc,	Classroom Lecture and Discussion	1
3-4	Setting Deep Learning environment: Introduction to TensorFlow and PyTorch,	Classroom Lecture and Discussion	1, 2
5-6	Concept of Neural Network, Gradient descent, Stochastic Gradient descent, Perceptron, Multilayer Perceptron, Backpropagation, Optimization.	Classroom Lecture and Discussion	2, 3
7	**Activation Functions:** Sigmoid function, Hyperbolic Tangent function, ReLu-Rectified Linear units, SoftMax function.	Classroom Lecture and Discussion	2, 3
8	**Stochastic Optimization:** Gradient Descent, Stochastic gradient Descent, RMSProp, Adadelta, Adam, etc.	Classroom Lecture and Discussion	3,4
9	**Convolutional Neural Networks (CNN):** Overview of different CNN architectures, Pooling, Padding, Max Padding, Building, Training and Evaluating CNN,	Classroom Lecture and Discussion	2, 3, 4
10	**Application:** image classification (transfer learning, fine tuning, object detection, etc.), Autoencoders, Word2Vec.	Classroom Lecture and Discussion	4,5
11	**Introduction to Recurrent Neural Networks (RNN):** Overview of RNN architectures, training, and optimization,	Classroom Lecture and Discussion	2, 3, 5
12	**Application:** Natural Language Processing, Sentiment Analysis, etc.	Classroom Lecture and Discussion	3, 4
13	**Advanced Architectures and Techniques:** Reinforcement Learning, Autoregressive models (NLMs), Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs) for Image Generation,	Classroom Lecture and Discussion	4, 5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
14	Long Short-Term Memory (LSTM) Networks for Sequential Data, Transformer Models for Language Understanding (e.g., BERT, GPT).	Classroom Lecture and Discussion	3, 4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation, Practical Implementations	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Bishop, C. M., & Bishop, H. (2024). Deep learning: Foundations and concepts. Springer.
ii. Prince, S. J. (2023). Understanding Deep Learning. MIT Press.
iii. Courville, A., Goodfellow, I., and Bengio, Y. (2016). Deep Learning (Adaptive Computation and Machine Learning series), MIT Press, USA.

Supplementary Readings:

i. Ekman, M. (2021). Learning deep learning: Theory and practice of neural networks, computer vision, natural language processing, and transformers using TensorFlow. Addison-Wesley Professional.
ii. Bishop, C. M., (2006). Pattern Recognition and Machine Learning. Springer Science+ Business Media, LLC.
iii. Charu C, A. (2023). Neural networks and deep learning: a textbook. 2nd Edition, Springer.
iv. Julian, D. (2018). Deep Learning with Pytorch Quick Start Guide: Learn to Train and Deploy Neural Network Models in Python, Packt Publishing.
v. Géron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, Second Edition. O'Reilly Media, Inc.

Chollet, F. (2021). Deep Learning with Python, 2nd Edition, Manning.

Optional courses for semester 2

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5211	Incomplete Data Analysis	Elective	3.0	100

1. Rationale of the Course:

This course is essential for a comprehensive understanding of modern data analysis techniques, as real-world datasets often contain missing or incomplete information. Students can effectively handle and interpret datasets with missing values, leading to more accurate and reliable analytical results. Understanding techniques for imputation in the context of incomplete data can significantly enhance one's ability to make informed decisions and draw meaningful insights from complex datasets.

2. Course Objectives:

This course is primarily designed to provide students with the fundamentals of incomplete data analysis and applications. The specific objectives include:

- To understand the types of incomplete data and learn how to identify and classify them in real-world datasets.
- To learn various techniques to effectively deal with incomplete data without introducing bias or distorting the analysis.
- To develop the understanding and applying different imputation methods to handle incomplete data in different contexts.
- To develop the ability to incorporate incomplete data into advanced statistical models.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to identify and describe different types of missing data mechanisms.	3	2	2	1	2
2. Students should be proficient in applying various imputation techniques to handle missing data effectively.	3	3	2	3	2
3. Students will be able to recognize and evaluate the potential biases that incomplete data can introduce into statistical analyses.	2	3	3	2	2
4. Students will gain a fundamental understanding of missing data models and their application in statistical analysis.	1	2	3	3	2
5. Students should be able to interpret and communicate the results of analyses conducted on incomplete data effectively.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Introduction to Incomplete Data:** Definition of incomplete data, Types of missing data, Importance of handling incomplete data in statistical analysis.	Classroom Lecture and Discussion	1
3-4	**Missing Data Mechanisms:** Understanding different missing data mechanisms, Methods for identifying missing data mechanisms. Dealing with various missing data patterns.	Classroom Lecture and Discussion	1, 2
5	**Traditional Approaches to Handling Missing Data:** Complete case analysis and its limitations, Available case analysis and its implications.	Classroom Lecture and Discussion	2
6	**Methods for imputing missing values:** Mean imputation, regression imputation, and last observation carried forward.	Classroom Lecture and Discussion	2,3
7-8	**Modern Imputation Techniques:** Multiple imputation methods, Expectation-maximization algorithm, K-nearest neighbor imputation, Model-based imputation techniques.	Classroom Lecture and Discussion	3, 4
9	**Multiple Imputation by Chained Equations (MICE):** Explanation of the MICE approach. Difference with other imputation methods. Principles behind the MICE algorithm. MICE to handle imputation process in a chained manner.	Classroom Lecture and Discussion	3, 4
10	**Sensitivity Analysis for Incomplete Data:** Understanding the impact of missing data on analysis results, performing sensitivity analysis.	Classroom Lecture and Discussion	3, 4
11	Techniques for testing the robustness of various statistical methods.	Classroom Lecture and Discussion	3,4
12	**Advanced Methods for Handling Incomplete Data:** Maximum likelihood estimation, Bayesian methods for handling missing data,	Classroom Lecture and Discussion	4, 5
13-14	Nonparametric methods for handling missing data, Machine learning techniques for handling missing data.	Classroom Lecture and Discussion	3,4,5

5. Mapping CLOs with the Teaching-Leaning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings

i. Van, B. S. (2021): Flexible Imputation of Missing Data, 2nd Edition, Chapman and Hall/CRC, New York.
ii. Enders, C. K. (2022). Applied missing data analysis. Guilford Publications.
iii. He, Y., Zhang, G., & Hsu, C. H. (2021). Multiple imputation of missing data in practice: Basic theory and analysis strategies. Chapman and Hall/CRC.

Supplementary Readings:

i. Little, R. J. A. & Rubin, D. B. (2019): Statistical Analysis with Missing Data, 3rd Edition, John Wiley, New York.
ii. Graham, J. W. (2012): Missing Data: Analysis and Design, Springer, New York.
iii. Molenberghs, G., Fitzmaurice, G., Kenward, M. G., Tsiatis, A., & Verbeke, G. (Eds.). (2014). Handbook of missing data methodology. CRC Press.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5212	Robust Statistics	Core	3.0	100

1. Rationale of the Course:

This course is essential in today's data-driven world as it focuses on statistical methods that are resistant to outliers and deviations from standard assumptions. In a diverse range of fields such as finance, healthcare, and engineering, real-world data often contains anomalies that can significantly impact analysis. This course equips students with techniques to handle such challenges, ensuring accurate and reliable results even in the presence of outliers.

2. Course Objectives:

This course is primarily designed to provide students with the fundamentals of robust statistics and applications. The specific objectives include:

- To enable students to master in handling outliers and deviations and Familiarize students with various robust statistical models.
- To provide practical, hands-on experience in applying robust statistical techniques to real-world scenarios.
- To cultivate critical thinking skills by encouraging students to assess data quality, identify outliers, and make informed decisions.
- To develop students' ability to communicate complex statistical findings clearly and concisely, enabling them to convey the impact of robust methods on data analysis outcomes to both technical and non-technical stakeholders.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to demonstrate proficiency in handling outliers and deviations from standard assumptions.	3	2	2	1	2
2. Students should be able to choose suitable robust models and algorithms for various types of data.	3	3	2	3	2
3. Students should be capable to apply robust statistical methods to real-world problems.	2	3	3	2	3
4. Students should be capable of interpreting results critically to draw meaningful conclusions and make data-driven decisions.	1	2	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Introduction to Robustness:** Concept of Robustness, deviations from parametric models and estimation theory, Classical Versus Robust Approaches to Statistics.	Classroom Lecture and Discussion	1
2-3	Robust Location and Dispersion Estimates, M- Estimates of Location with Known Scale, M- Estimates of Scale.	Classroom Lecture and Discussion	1, 2

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
4	Simultaneous M- Estimates of Location and Scale, Numerical Computation of M-Estimates.	Classroom Lecture	2, 3
5-6	Influence Function, Breakdown Point, Gross-Error Sensitivity, Local-Shift Sensitivity.	Classroom Lecture	3
7-8	**Balancing Robustness:** Rejection Point, Maximum Asymptotic Bias; Balancing Robustness and Efficiency, Identification of Outliers.	Classroom Lecture and Discussion	3, 4
9	**Robust Methods in Correlation and Regression:** Robust Correlation Estimates, Linear Regression Models with Fixed Predictors: Regression M- Estimates.	Classroom Lecture and Discussion	3, 4
10	Models with Random Predictors: MM-Estimate, LMS-Estimate, S- Estimate, LTS Estimate, Tau Estimate.	Classroom Lecture	3, 4
11-12	**Robustness in Statistical Testing:** The Influence Function for Tests, Classes of Tests, Optimally Bounding the Gross-Error Sensitivity,	Classroom Lecture and Discussion	3, 4
13-14	Extending the Change-of-Variance Function to Tests, Lumbert's Approach, Eplett's Approach, M-Tests for a Simple Alternative.	Classroom Lecture and Discussion	3, 4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examinations.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Huber (2009). Robust Statistics, 2nd Edition, John Wiley & Sons.
ii. Maronna, R. A., Martin, R. D., Yohai, V. J., & Salibián-Barrera, M. (2019). Robust statistics: theory and methods (with R). John Wiley & Sons.

Supplementary Readings:

i. Maronna, R. A., Martin, R.D., & Yohai, V.J. (2019). Robust Statistics: Theory and Methods, John Wiley & Sons.
ii. Wilcox, R. R. (2023). A guide to robust statistical methods. Springer Nature.
iii. Jureckova, J., & Picek, J. (2021). Robust statistical methods with R. 2nd Edition, Chapman and Hall/CRC.
iv. Hampel, F. R., Ronchetti, E. M., Rousseeuw, P. J. & Stahel, W.A. (1986). Robust Statistics: The Approach Based on Influence Functions, John Wiley & Sons.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5213	Semiparametric Regression	Elective	3.0	100

1. Rationale of the Course:

This course is designed for more flexible modeling of data compared to purely parametric methods. It can handle a wide range of functional relationships between variables without making strict distributional assumptions. It provides the ability to address nonlinear relationships, handle high-dimensional data, and make predictions without rigid distributional assumptions. This course equips students with valuable analytical skills, fosters research advancements, and empowers data analysts to effectively model intricate relationships in data.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Semiparametric Regression. The specific objectives include:

- To develop a deep understanding of the concept of semiparametric regression.
- To learn how to select appropriate semiparametric models, assess model goodness-of-fit, and make informed choices about model complexity.
- To gain the skills to model and interpret nonlinear relationships between variables to practical problems using semiparametric regression.
- To apply semiparametric regression to practical problems in fields such as economics, epidemiology, and social sciences.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will gain a comprehensive understanding of semiparametric regression.	3	2	2	1	2
2. Students will be able to apply appropriate model selection techniques to identify and justify the choice of semiparametric models	3	3	2	3	2
3. Students will be skilled in effectively capturing complex data patterns and trends.	2	3	3	2	2
4. Students will be capable to applying semiparametric regression in various real-life problems.	1	2	3	3	2
5. Students will be able to interpret the results of semiparametric regression models in a clear and concise manner.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Parametric and Nonparametric Regression:** Review of parametric regression models (e.g., linear regression), Introduction to nonparametric regression (e.g., kernel regression), Strengths and limitations of parametric and nonparametric approaches.	Classroom Lecture and Discussion	1
3	**Penalized Splines:** Penalized Spline Basics, Choosing the Smoothing Parameter, Choosing the Basis Size, Checking the Residuals	Classroom Lecture and Discussion	1, 2
4	Mixed Model-based Penalized Splines, Variability Brands, Flexible regression model, Fractional polynomial function.	Classroom Lecture and Discussion	2, 3
5-6	**Hypothesis Testing and Bayesian Penalized Splines:** Hypothesis testing in Semiparametric Regression, Bayesian Penalized Splines, Choosing Between Different Penalized Spline Approaches, Penalized Splines with Factor Effects.	Classroom Lecture and Discussion	3
7-8	**Generalized Additive Models:** Generalized Linear Models, Generalized Additive Models, Model Selection, Extension to Vector Responses, Extension to Factor-by-Curve Interactions.	Classroom Lecture and Discussion	3, 4
9-10	**Semiparametric Regression Analysis of Group Data:** Additive Mixed Models, Models with Group-Specific Curves, Marginal Models, Extension to Non-Gaussian Response Variables.	Classroom Lecture and Discussion	4
11-12	**Bivariate Function Extensions:** Bivariate Nonparametric Regression, Geoadditive Models, Varying-Coefficient Models, Covariance Function Estimation. Estimating a Covariance Function with Sparse Data.	Classroom Lecture and Discussion	4, 5
13-14	**Robust and Quantile Semiparametric Regression:** Quantile Regression, Parameter estimation, Asymptotic properties, Applications, Quantile Semiparametric Regression, Parameter estimation, Applications. Local Polynomial Fitting, Kernel Machines.	Classroom Lecture and Discussion	4, 5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Harezlak J., Ruppert D. & Wand M. P. (2018): Semiparametric Regression with R, Springer.

Supplementary Readings:

i. Ruppert, D., Wand, M.P., & Carroll, R.J. (2003). Semiparametric Regression. Cambridge University Press.
ii. Yatchew, A. (2003). Semiparametric regression for the applied econometrician. Cambridge University Press.
iii. Härdle, W., Müller, M., Sperlich, S., & Werwatz, A. (2004). Nonparametric and semiparametric models, Berlin: Springer.
iv. McCulloch, C. E., & Searle, S. R. (2004). Generalized, linear, and mixed models. John Wiley & Sons.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5214	Applied Stochastic Process and Stochastic Simulation	Elective	3.00	100

1. Rationale of the Course:

This course is crucial for understanding and modeling the inherent randomness in various real-world systems. This field is pivotal in sectors like finance, where it aids in modeling market fluctuations, in engineering for reliability testing, and in telecommunications for network traffic analysis. By equipping students with the ability to model, analyze, and simulate stochastic processes, the course offers valuable tools for tackling complex, dynamic systems where uncertainty is a key factor.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Applied Stochastic Process and Stochastic Simulation. The specific objectives include:

- To understand fundamental concepts and methodologies in stochastic processes.
- To acquire skills in statistical inference and estimation techniques related to stochastic processes.
- To learn to apply stochastic models to analyze and solve problems in various fields.
- To gain proficiency in simulating stochastic processes, using tools like Monte Carlo simulation, to model and analyze complex systems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to understand and apply concepts of both reducible and irreducible Markov Chains, including their applications.	3	2	2	1	2
2. Students will be able to develop skills in statistical inference related to Markov Chains, including estimating transition probabilities.	3	3	2	3	2
3. Students will be able to gain proficiency in analyzing and estimating parameters in queuing models.	2	3	3	2	3
4. Students will be able to understand and apply renewal theory and processes in practical scenarios.	2	2	3	3	3
5. Students will be able to acquire the ability to simulate various stochastic processes using advanced techniques.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-2	**Markov Chains and Applications:** Concept of Irreducible and Reducible Markov Chains. Limiting properties of Reducible Chains. Random Walk Model, The Gambler's Ruin Problem, Mean Time Spent in Transient State. Time Reversible Markov Chain, Markov Decision Process, Markov Chain Monte Carlo Methods, Hidden Markov Chains.	Classroom Lecture and Discussion	1
3-4	**Estimation and Statistical Inference related to Finite Markov Chains:** Maximum Likelihood Estimates of Transition Probabilities. Testing for a given Transition Probability Matrix, Stationarity of Transition Probability Matrix, Order of Markov Chain, First Order Markov Dependence.	Classroom Lecture and Discussion	1, 2
5	**Estimation related to M/M/1 Queuing Model:** Point and Interval estimates of Arrival Rate, Service Rate, Server Utilization Rate of an M/M/1 queuing model.	Classroom Lecture and Discussion	3
6	**Renewal Process:** Renewal Process in continuous time, Distribution of number of Renewals. Renewal Function, Renewal Density and Renewal Equation. Moments of Number of Renewals. Stopping Time and Wald's Equation. Convergence of average Renewal rate, Elementary Renewal Theorem and their applications.	Classroom Lecture and Discussion	4
7-8	**Renewal Theory and Applications:** Ordinary, Delayed and Equilibrium Renewal Process, Probability Generating Function of Renewal Process. Central Limit Theorem for Renewals. Renewal Reward Process, Regenerative Process, Two-Stage Renewal Process, Computation of Renewal Function.	Classroom Lecture and Discussion	4
9	**Brownian Motion, Stationary Process and Time Series:** Brownian Motion, Variations on Brownian Motion, White Noise. Second Order Process, Stationary and Weekly Stationary Process, Gaussian Process. Models of Time Series.	Classroom Lecture and Discussion	4
10-11	**Branching Process:** Meaning, Moments of Branching Process, Properties of Generating Function of Branching Process. Probability of Ultimate Extinction, Distribution of Total Number of Progeny, Conditional Limit Laws, Generalization of Classical Branching Process, Continuous Time Branching Process, Age Dependent Branching Process.	Classroom Lecture and Discussion	5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
12-13	**Social and Behavioral Process:** Social Mobility & its properties. Industrial Mobility for Labour. Educational Advancement, Labour Force Planning and Management. Markov Model in Biological Sciences and Business Management.	Classroom Lecture and Discussion	5
14	**Stochastic Simulation:** Analyzing Homogenous Poisson Process, Non-homogenous Poisson Process, Markov Chain, Continuous Time Birth and Death Model, Renewal Process, Branching Process, Multilevel Queuing System by Monte Carlo Simulation.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Ross, S. M. (2023): Introduction to Probability Models, 13th edition, Academic Press, an imprint of ELSEVIER.
ii. Medhi, J. (2009): Stochastic Process, 3rd revised edition, New Age International (P) Ltd., Publishers, New Delhi.

Supplementary Readings:

i. Gallager, R. G. (2013). Stochastic processes: theory for applications. Cambridge University Press.
ii. Bhat B R (2004): Stochastic Models, Analysis and Applications, New Age International (P) Ltd., Publishers, New Delhi.
iii. Dobrow, R. P. (2016). Introduction to stochastic processes with R. John Wiley & Sons.
iv. Medhi, J. (2006): Stochastic Models in Queuing Theory, 2nd edition, Academic Press, an imprint of ELSEVIER.
v. Minh, D. L. (2001): Applied Probability Models, Thomson Duxbury, California.
vi. Prabhu, N. U. (1980): Stochastic Process, Springer Varleg, New York.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5215	Advanced Design of Experiments	Elective	3.00	100

1. Rationale of the Course:

This course is essential for delving into the complexities of experimental planning and analysis in modern research and industrial applications. It aims to equip researchers and practitioners with the skills to efficiently design experiments that can handle multiple variables and their interactions, optimize responses, and draw reliable conclusions while minimizing resource usage. The course is particularly beneficial in fields where experimentation precision and accuracy are paramount.

2. Course Objectives:

This course is primarily designed to provide students with a fundamental understanding of Advanced Design of Experiment. The specific objectives include:

- To acquire knowledge in advanced design of experiments methodologies to address complex research questions efficiently.
- To Learn to apply statistical tools for analyzing experimental data, focusing on model assumptions, diagnostics, and resolving issues from violated assumptions.
- To gain expertise in optimizing experimental designs for accuracy and efficiency.
- To build practical skills in planning, conducting, and analyzing controlled experiments, with a focus on applying theoretical knowledge to real-world problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to apply linear estimation and hypothesis testing in experimental data analysis.	3	2	2	1	2
2. Students will demonstrate the ability to diagnose model fit issues and implement remedial measures.	3	3	2	3	2
3. Students will gain the skill to design fractional factorial experiments and understand the implications of confounding and aliasing in these designs.	2	3	3	2	2
4. Students will learn to effectively use and analyze two-level and multi-level factorial designs.	1	2	3	3	3
5. Students will be able to design and analyze complex experimental setups such as split-split-plot and balanced incomplete block designs.	1	3	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Linear Estimation:** Linear Hypothesis, Model Assumptions and Diagnostics, Remedial measures for violated assumptions.	Classroom Lecture and Discussion	1
2	General Principles in Controlled Experiments, Strategies in Planning Experimental Programs, Statistical Power and Sample Size Determination.	Classroom Lecture and Discussion	1, 2
3-4	**Fractional Factorial Design:** Concept of Fractional Factorial Designs, Analysis for Fractional Factorial Designs, Optimization and Efficiency in Fractional Factorial Designs, Confounding, Principles of confounding and aliasing.	Classroom Lecture and Discussion	3
5	**Two-Level Fractional Factorial Design:** Introduction to Two-Level Fractional Factorial Designs, Analysis of Two-Level Fractional Factorial Designs, Hands-on analysis using statistical software	Classroom Lecture and Discussion	4
6	**Three-Level and Mixed-Level Factorial:** Introduction to Three-Level Factorial Designs, Mixed-Level Factorial Designs, Statistical Analysis for Three-Level and Mixed-Level Designs	Classroom Lecture and Discussion	4
7-8	**Split-Split-Plot Design:** Overview of experimental designs with a focus on split-split-plot structures, Principles of constructing split-split-plot designs, Analysis of Split-Split-Plot Designs	Classroom Lecture and Discussion	3, 4, 5
9-10	**Balanced Incomplete Block Design (BIBD)**: Inter and Intra-Block Analysis, Missing Observation in BIBD.	Classroom Lecture and Discussion	4 ,5
11-12	Missing Plot, Galois Field and Finite Projective Geometry and its Application, Groups of Experiments, Optimality of Design.	Classroom Lecture and Discussion	4, 5
13-14	Response Surface Methods, Method of Steepest Ascent Analysis of Second-Order Response Surface Design, Palatability, Carraraites in Factorial Experiments.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Montgomery, D. C. (2020): Design and Analysis of Experiments, 10th Edition, John Wiley and Sons, New York.

Supplementary Readings:

i. Lawson, J. (2014). Design and Analysis of Experiments with R. CRC Press.
ii. Das, M. N. and Giri, N. C. (1997): Design and Analysis of Experiments, 2nd Edition, New International (P) Ltd., India
iii. Dean, A., Voss, D. and Draguljić, D. (2017). Design and analysis of experiments. New York, NY: Springer New York.
iv. Kempthorne, O. (1952): The Design and Analysis of Experiments, Wiley, New York.
v. Graybill, F. A. (1961): An Introduction to Linear Statistical Models, Vol. I, Mcgrow-Hill, New York.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5216	Multivariate and Clustered Survival Data Analysis	Elective	3.0	100

1. Rationale of the Course:

This course is designed to equip students with the tools to analyze complex, interrelated survival data. The knowledge gained from this course can facilitate the exploration of the impact of various covariates and cluster effects on survival outcomes, thereby providing insights that can inform more effective public health interventions and policies. This course fosters the development of advanced analytical skills that are increasingly in demand in both academic and industrial research settings.

2. Course Objectives:

This course is primarily designed to teach students advanced data visualization techniques and their applications. The specific objectives include:

- To understand the principles and techniques involved in analyzing multivariate survival data.
- To develop the necessary skills and knowledge to analyze survival data that exhibit clustering.
- To enable to apply various statistical models in the context of analyzing multivariate and clustered survival data in real-world scenarios.
- To develop the ability to interpret and communicate the results of multivariate and clustered survival data analyses effectively.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to gain proficiency in a range of advanced multivariate survival analysis techniques.	3	2	2	1	2
2. Students will be able to effectively handle and analyze clustered survival data.	3	3	2	3	2
3. Students will be able to able to interpret the results of multivariate and clustered survival data analyses in the context of various research questions or hypotheses.	1	2	3	3	2
4. Students will be able to apply the knowledge gained from the course to practical research scenarios and understand the implications of multivariate and clustered survival data analysis in various fields.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Multivariate Survival Data:** Definition of multivariate survival data. Examples and scenarios where multivariate survival analysis is applicable.	Classroom Lecture and Discussion	1
2-3	**Bivariate Survival Analysis**: Techniques for analyzing the joint survival of two outcomes. Copulas and their application in bivariate survival analysis.	Classroom Lecture and Discussion	1
4-5	**Accelerated Failure Time Models**: Concept of accelerated failure time models. Comparison with proportional hazards models. Formulation of the accelerated failure time model equation. Maximum likelihood estimation in AFT models. Model Assumptions and Diagnostics,	Classroom Lecture and Discussion	1, 4
6	Weibull AFT Model: In-depth exploration of the Weibull accelerated failure time model. Applications and interpretation. Exponential AFT Model, etc.	Classroom Lecture and Discussion	1, 4
7-8	**Clustered Survival Data:** Definition of clustered or correlated survival data. Understanding intra-cluster correlation, Analysis of clustered survival data.	Classroom Lecture and Discussion	2
9-10	**Frailty Models:** Introduction to frailty models in the context of clustered survival data. Incorporating random effects to account for clustering.	Classroom Lecture and Discussion	2, 3
11	**Handling Time-Dependent Covariates**: Techniques for incorporating time-dependent covariates in survival models. Impact on risk estimates.	Classroom Lecture and Discussion	1, 4
12	**Meta-Analysis of Survival Data:** Approaches for meta-analysis of survival data from multiple studies. Combining results and addressing heterogeneity.	Classroom Lecture and Discussion	4
13-14	**Time-to-Event Analysis in Clinical Trials:** Application of multivariate and clustered survival analysis in the context of clinical trials. Regulatory considerations.	Classroom Lecture and Discussion	4

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings

i. Lee, E. T. and Wang, J. W. (2013): Statistical Methods for Survival Data Analysis, 4th Edition, Wiley Series, New York.

ii. Lawless, J. F. (2011). Statistical models and methods for lifetime data. John Wiley & Sons.

iii. Hosmer Jr, D. W., Lemeshow, S., & May, S. (2008). Applied survival analysis: regression modeling of time-to-event data, John Wiley & Sons.

Supplementary Readings:

i. David, G. K., & Mitchel, K. (2012). Survival analysis: a Self-Learning text. Springer

ii. O'Quigley, J. (2021). Survival Analysis: Proportional and Non-Proportional Hazards Regression, Springer International Publishing.

iii. Johnson, R. A. and Wichern, D. W. (2007): Applied Multivariate Statistical Analysis, 6th Edition, Pearson Education, Asia

ii. Newman, S. (2001): Biostatistical Methods in Epidemiology, Wiley, New York.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5217	Advanced Data Visualization	Core	3.0	100

1. Rationale of the Course:

This course is designed to meet the growing need for data professionals who can extract meaningful insights from complex data, communicate those insights effectively, and contribute to data-driven decision-making in today's data-centric world. It equips students with valuable skills that are applicable in a variety of professional contexts and contributes to their personal and career development.

2. Course Objectives:

This course is primarily designed to learn advanced data visualization techniques and their applications. The specific objectives include:

- To understand advanced data visualization techniques and perform in-depth data analysis and effectively visualize complex datasets.
- To communicate data insights and findings effectively, using visual storytelling and narrative techniques to make data more accessible and engaging.
- To apply advanced data visualization skills to real-world scenarios and projects.
- To gain knowledge and skills to create interactive data visualizations interactively and gain deeper insights.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to create interactive data visualizations and dashboards using relevant tools and libraries.	3	2	2	1	3
2. Students will be able to build and apply advanced chart types, including heatmaps and Sankey diagrams.	3	3	2	3	2
3. Students will be able to visualize geographic and spatial data effectively using advanced techniques.	2	3	3	3	3
4. Students will be able to implement network and time-series data visualizations, capturing dynamic relationships and trends.	1	2	3	3	3
5. Students will be able to handle high-dimensional data and integrate machine learning techniques for insightful data storytelling.	1	2	2	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Interactive Data Visualization:** Introduction to interactive data visualization, Tools, and libraries for creating interactive visualizations, Creating interactive dashboards.	Classroom Lecture and Discussion	1
3-4	**Advanced Chart Types:** Exploring specialized chart types (e.g., heatmaps, chord diagrams, Sankey diagrams), Use cases and scenarios for advanced chart types, building advanced charts using visualization libraries.	Classroom Lecture and Discussion	2
4	**Spatial and Geographic Data Visualization:** Visualizing geographic data with choropleth maps, Advanced techniques for geospatial visualization, Geospatial data analysis and visualization tools.	Classroom Lecture and Discussion	3
5-6	**Network Visualization:** Understanding network visualization and its applications, Creating network graphs and visualizing connections.	Classroom Lecture and Discussion	4
7-8	**Time-Series Data Visualization:** Time-series data visualization techniques, Visualizing temporal trends, seasonality, and anomalies, Real-time data visualization.	Classroom Lecture and Discussion	4
9	**Multidimensional Data Visualization:** Dealing with high-dimensional data, Parallel coordinates, and other multidimensional visualization techniques.	Classroom Lecture and Discussion	5
10	**Dimensionality reduction for visualization:** Introduction to High-Dimensional Data, Multidimensional Scaling (MDS), Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA).	Classroom Lecture and Discussion	5
11	**Advanced Data Mapping:** Mapping techniques for non-geographic data, Custom mapping, and data overlays.	Classroom Lecture and Discussion	5
12	**Autoencoders and Neural Networks:** Introduction to autoencoders for nonlinear dimensionality reduction. Training autoencoders and choosing architectures. Applications and comparison with traditional methods.	Classroom Lecture and Discussion	5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
13	**Machine Learning-Driven Visualizations:** The role of machine learning in data visualization, Automatic data visualization using machine learning, Enhancing data exploration with ML-driven techniques.	Classroom Lecture and Discussion	5
14	**Storytelling with Data:** Effective data storytelling techniques, creating data narratives and infographics, communicating insights to a non-technical audience, Exploring advanced visualization tools and libraries.	Classroom Lecture and Discussion	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Iliinsky, N. & Steele, J. (2011). Designing Data Visualizations, O'Reilly Media.
ii. Murray, S. (2013). Interactive Data Visualization for the Web: An Introduction to Designing with D3. O'Reilly Media.

Supplementary Readings:

i. Rahman, A., Abdulla, F., & Hossain, M. M. (2024). Scientific Data Analysis with R: Biostatistical Applications. Chapman & Hall/CRC Press.
ii. Rocchini, C., Marchiori, E., & Guadagnoli, A. (2019). Advanced Data Visualization, Springer.
iii. Kirk, A. (2019). Data visualisation: A handbook for data driven design. 2nd Edition, SAGE Publications Ltd.
iv. Camm, J.D., Cochran, J. J., Fry, M. J., Ohlmann, J. W. (2021). Data visualization: exploring and explaining with data, Cengage Learning.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5218	Artificial Intelligence	Elective	3.0	100

1. Rationale of the Course:

This course is designed to equip students with a profound understanding of the interplay between statistics and data science, acknowledging that these fields are integral to making sense of complex data sets in today's data-driven world. By delving into statistical modeling, data visualization, and advanced analytical methodologies, students will develop the necessary skills to derive meaningful insights from diverse data sources, thereby enabling informed decision-making in various domains.

2. Course Objectives:

The primary objective of this course is to focus on understanding Artificial Intelligence and its application. The specific objectives include:

- To acquire a comprehensive understanding of the fundamental concepts, theories, and methodologies basis of artificial intelligence.
- To gain practical experience in implementing AI algorithms and to understand how AI is utilized in real-world scenarios.
- To cultivate critical thinking skills by examining the strengths and limitations of various AI approaches
- To understand the importance of ethical considerations in the development and deployment of AI systems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be able to understand the history and foundational concepts of Artificial Intelligence.	3	2	2	1	2
2. Students will be able to analyze AI agents' interactions with environments and apply rationality principles.	3	3	2	3	2
3. Students will be able to master various AI problem-solving techniques, including search strategies and heuristic functions.	2	3	3	2	2
4. Students will be able to gain knowledge in adversarial search, knowledge-based reasoning, and first-order logic.	1	2	3	3	2
5. Students will be able to learn probabilistic reasoning and Bayesian networks for decision-making in fields like healthcare and finance.	1	3	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Introduction:** Introduction to AI, foundation, and history of AI.	Classroom Lecture and Discussion	1
2	**Agents:** Agents and Environment, The concept of rationality, the nature of environment, and structure of agents.	Classroom Lecture and Discussion	2
3	**Problem Solving – Search:** Problem solving agents, example problems, searching for solutions, uniformed and informed search strategy, and heuristic functions.		3
4	**Adversarial Search:** Games, Alpha-Beta Pruning, Imperfect real-time decision, Stochastic games, partially observed and state-of-the-art games, alternative approaches.	Classroom Lecture and Discussion	3
5-6	**Knowledge and Reasoning:** Knowledge-based agents, the Wumpus world, Logic, Propositional logic, Propositional theorem proving, effective propositional model checking, Agents based on propositional logic.	Classroom Lecture and Group work	4
7-8	**First Order Logic Reasoning:** Representation revisited, syntax and semantics of first-order logic, using first-order logic, Knowledge engineering in first-order logic, inference in first-order logic.	Classroom Lecture and Group work	4
9	**Uncertainty in AI and Expert System:** Quantifying uncertainty, Probabilistic Reasoning, Neural Fuzzy Expert System	Classroom Lecture and Group work	4
10-11	**Uncertainty in AI and Bayesian Network:** Learning Bayesian Network structures from data. Expert elicitation and knowledge engineering for BNs. Handling continuous and discrete variables in BNs. Modeling temporal relationships with Dynamic Bayesian Networks.	Classroom Lecture and Group work	5
12-13	**Decision Making with Bayesian Networks:** Utility theory and decision nodes. Influence diagrams and decision networks. Incorporating decision-making in BN models. Case studies in healthcare, finance,	Classroom Lecture and Group work	5

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
	and natural language processing, Real-world projects applying BN inference.		
14	**Dynamic Probabilistic Models:** Statistical Learning, learning with incomplete data, learning with hidden data.	Classroom Lecture and Group work	5

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Russell, S.J. and Norvig, P. (2021). Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, London.
ii. Poole, D.L. and Mackworth, A.K. (2023). Artificial Intelligence: foundations of computational agents. 3rd Edition, Cambridge University Press.
iii. Murphy, K.P. (2012). Machine learning: a probabilistic perspective. MIT Press.

Supplementary Readings:

i. Bishop, C.M. (2006). Pattern Recognition and Machine Learning by Christopher M. Bishop. Springer Science+ Business Media, LLC.
ii. Bengio, Y., Goodfellow, I. and Courville, A. (2017). Deep learning (Vol. 1). Cambridge, MA, USA: MIT Press.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0912-5219	Epidemiological Modelling for Public Health	Elective	3.0	100

1. Rationale of the Course:

This course is designed to equip students with the skills to analyze disease patterns, assess risk factors, and measure the impact of illnesses. Through this modeling, future public health professionals can develop effective strategies for disease prevention and control and make informed decisions on healthcare policies and resource allocation. This knowledge is fundamental in addressing current and emerging health challenges, ensuring a proactive and evidence-based approach to public health management.

2. Course Objectives:

The primary objective of this course is to focus on understanding the issues in public health and application of epidemiological modelling for communicable disease control. The specific objectives include:

- To understand the basic concept of public health and public health approaches.
- To understand the bias in epidemiological studies.
- To learn the dynamics of disease transmission and modelling infectious disease.
- To apply techniques for designing and evaluating prevention programs.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students will be competent in using statistical techniques to evaluate disease patterns, pinpoint risk factors, and derive meaningful inferences from epidemiological data.	3	2	2	1	2
2. Students will gain the ability to organize and carry out epidemiological research techniques for gathering data.	3	3	2	3	2
3. Students will learn how to assess the effectiveness of public health interventions through statistical analysis.	2	3	3	2	2
4. Students will be proficient in effectively communicating epidemiological results to diverse audiences, bridging the gap between data analysis and public health action.	2	3	3	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1	**Concept of Health:** Concept of health, Dynamics, Measurement of health, Determinants of health, Measuring health Impact.	Classroom Lecture and Discussion	1
2	**Introduction to Public Health and Epidemiology:** Overview of public health and its significance. Public Health Approaches. Core Functions of Public Health, Steps in Public Health System. Bangladesh Public Health System and Achievements. Epidemiolocal indicators, Objectives, Branches and Role of epidemiology in public health.	Classroom Lecture and Discussion	1, 2
3	**Concept of Disease:** Concept of disease, States of disease in an individual, Concept of disease occurrence, factors causing human disease.	Classroom Lecture and Discussion	2
4	**Measuring Burden of Disease:** Concept, Mortality & Morbidity Measures. **Disability Adjusted Life Years (DALY):** Concept and Necessity of Measuring DALY, Measurement of DALY, Problems in DALY. Quality of Life Measures, Economic Measures.	Classroom Lecture and Discussion	3
5	**Types of Disease and Dynamic of Disease Transmission:** Types of disease, Infectious and noninfectious disease, Genetic transmission and other (e.g., blood, saliva, etc.) transmission disease. Modes of disease transmission. Brief Introduction to Dengue, COVID-19, NIPAH, Ebola, STI, HIV/AIDS, Diabetes, Mellitus, Tuberculosis, Diarrhea and Water Borne Diseases, Cardiovascular Disease, Cancer. Modes of transmission of each transmission disease. Risk factors and Prevention Strategy.	Classroom Lecture and Discussion	2,3
6	**Modeling Infectious Diseases:** Introduction to models used in modelling infectious disease, Assumptions. **The SIR Model:** Basic Model Dynamics, Estimating the parameters of SIR model. Concept of Basic and Effective Reproduction Number, Herd Immunity,	Classroom Lecture and Discussion	4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
	Force of Infection. Equilibrium points in SIR model. Limitations of the basic SIR model.		
7	**Modifications and Extensions of SIR Model:** Model Dynamics of SIRS model, SEIR model. Vaccination in the Basic Model and Effective Vaccination Coverage. SIR models with vital dynamics.	Classroom Lecture and Discussion	4
8	**Disease Specific Modelling:** Modeling for Dengue, Nipah virus, Tuberculosis, HIV/AIDS, STI. Epidemiological Models used for modeling infectious disease in Bangladesh.	Classroom Lecture and Discussion	3, 4
9-10	**Causal Inference from Epidemiological Study:** Concept of Bias. Confounding Effect, Identifying Confounders, Confounding. Methods for controlling Confounding: Method of restriction, pros and cons of restriction as a means to control for confounding, restriction to control for confounding-by-indication; Method of stratification, stratum-specific associations; Method of matching; Randomization.	Classroom Lecture and Discussion	3, 4
11	**More on Causal Inference:** **Interaction:** Concept, Identifying Interaction, and its impact. **Effect Modification:** Concept of effect modification, synergy between exposure variables. Interaction vs. effect modification vs. confounding. Evaluation of effect modification, effect modification in clinical research.	Classroom Lecture and Discussion	4
12	**Impact of Environmental and Genetic Factors in Disease Causation:** Introduction to environmental health and its impact on public health. Importance of studying environmental ang genetic aspects for Epidemiological modelling. Interaction between Genetic and Environmental Risk Factors.	Classroom Lecture and Discussion	2, 3, 4
13-14	**Application of Epidemiology in Public Health:** Overview disease prevention and control. Types of prevention approaches. Designing and implementing effective prevention programs.	Classroom Lecture and Discussion	4

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
	Evaluating prevention programs in terms of epidemiological impacts (Lives saved, Infections Averted, DALYs saved) and cost-effectiveness analysis (Cost per lives saved, Infections averaged, Cost-Benefit Analysis). Influence of epidemiological research on public health policy.		

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Classroom Lecture, Interactive Group Discussion, Multimedia Presentation	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examinations.
CLO-2		
CLO-3		
CLO-4		

6. Assessment and Evaluation

As per the process outlined in Part D.

7. Learning Materials

Recommended Readings:

i. Celentano, D.D. & Szklo, M. (2018). Gordis Epidemiology, 6th Edition, Elsevier, Amsterdam.
ii. Martcheva, M. (2015). An Introduction to Mathematical Epidemiology, Springer New York, NY.
iii. Caron, R. M. (2022). Population health, epidemiology, and public health: management skills for creating healthy communities. Health Administration Press.

Supplementary Readings:

i. Hens, N., Shkedy Z., Aerts, M., Faes, C., Damme, P. V. and Beutels, P., (2012): Modeling Infectious Disease Parameters Based on Serological and Social Contact Data, Springer Science Plus Business Media New York.
ii. Kenneth, J. and Rothman, S. G. (2012): Modern Epidemiology, 3rd Edition, LWW.

LAB/Practical Courses for Semester 2

Course Code: 0542-5221	**Course Title:** LAB - Advanced Classical and Bayesian Inference	**Course Type:** LAB	**Credit Value:** 1.0	**Total Marks:** 100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5201: Advanced Classical and Bayesian Inference" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct analysis of Advanced Classical and Bayesian Inference.	1	2	1	3	3
2. Students should be able to apply Advanced Classical and Bayesian Inference techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	**Topic**	**Teaching-Learning Strategy**	**Corresponding CLOs**
1-14	As per the theoretical course "0542-5201: Advanced Classical and Bayesian Inference".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5222	LAB – Deep Learning	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0610-5202: Deep Learning" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Deep Learning analysis.	1	2	1	3	3
2. Students should be able to apply Deep Learning techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0610-5202: Deep Learning".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5223	LAB - Incomplete Data Analysis	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5211: Incomplete Data Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Incomplete Data Analysis.	1	2	1	3	3
2. Students should be able to apply Incomplete Data Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5211: Incomplete Data Analysis".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value: 1.0	Total Marks:
0542-5224	LAB – Robust Statistics	LAB		100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5212: Robust Statistics" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Robust Statistical analysis.	1	2	1	3	3
2. Students should be able to apply Robust Statistics Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5212: Robust Statistics".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5225	LAB - Semiparametric Regression	LAB	**Value:** 1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5213: Semiparametric Regression" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Semiparametric Regression analysis.	1	2	1	3	3
2. Students should be able to apply Semiparametric Regression analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5213: Semiparametric Regression".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5226	LAB - Applied Stochastic Process and Stochastic Simulation	LAB	**Value**: 1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5214: Applied Stochastic Process and Stochastic Simulation" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Applied Stochastic Process and Stochastic Simulation analysis.	1	2	1	3	3
2. Students should be able to apply Applied Stochastic Process and Stochastic Simulation Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5214: Applied Stochastic Process and Stochastic Simulation"	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit	Total Marks:
0542-5227	LAB - Advanced Design of Experiment	LAB	**Value:** 1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5215: Advanced Design of Experiment" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Advanced Design of Experiment analysis.	1	2	1	3	3
2. Students should be able to apply Advanced Design of Experiment Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5215: Advanced Design of Experiment".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0542-5228	LAB - Multivariate and Clustered Survival Data Analysis	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0542-5216: Multivariate and Clustered Survival Data Analysis" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Multivariate and Clustered Survival Data analysis.	1	2	1	3	3
2. Students should be able to apply Multivariate and Clustered Survival Data Analysis techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0542-5216: Multivariate and Clustered Survival Data Analysis".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course	Credit Value:	Total Marks:
0610-5229	LAB - Advanced Data Visualization	**Type:** LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0610-5217: Advanced Data Visualization" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Advanced Data Visualization.	1	2	1	3	3
2. Students should be able to apply Advanced Data Visualization techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0610-5217: Advanced Data Visualization".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0610-5230	LAB - Artificial Intelligence	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0610-5218: Artificial Intelligence" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Artificial Intelligence analysis.	1	2	1	3	3
2. Students should be able to apply Artificial Intelligence techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0610-5218: Artificial Intelligence".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Course Code:	Course Title:	Course Type:	Credit Value:	Total Marks:
0912-5231	LAB – Epidemiological Modelling for Public Health	LAB	1.0	100

1. Rationale of the Course:

This course is designed to solve some practical problems by using statistical tools that are learned in the theoretical course "0912-5219: Epidemiological Modelling for Public Health" by using computer programming and statistical software.

2. Course Objectives:

The major objectives of this course include:

- To analyze data using statistical tools that are learned in the theoretical course.
- To make a scientific report based on practical problems.

3. Course Learning Outcomes (CLOs) and Mapping of CLOs with PLOs

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5
1. Students should be able to use specialized statistical software, such as R, Python, or SPSS, to conduct Epidemiological Modelling analysis for Public Health.	1	2	1	3	3
2. Students should be able to apply Epidemiological Modelling techniques to real-world research and industry problems.	1	3	1	3	3
3. Students will learn how to make a scientific report based on statistical results.	1	3	1	3	3

4. Course plan specifying content, CLOs, co-curricular activities (if any), teaching-learning, and assessment strategy mapped with CLOs

Week	Topic	Teaching-Learning Strategy	Corresponding CLOs
1-14	As per the theoretical course "0912-5219: Epidemiological Modelling for Public Health".	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	1, 2, 3

5. Mapping CLOs with the Teaching-Learning & Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Lab Exercises, Interactive Workshops, Hands-on Coding Sessions, Case Studies, Group Discussions, Project-Based Learning.	Quizzes, Oral questioning, Assignments, Class tests and performance, Presentations, and Semester end examination.
CLO-2		
CLO-3		

6. Assessment and Evaluation

As per the process outlined in Part D.

Part D
Grading, Evaluation & Other Operational Requirements

1. Related Operational Requirements

a. Total weeks in a semester – 26 weeks.

b. Total class-weeks in a semester – 14 weeks.

c. Classes per week:
- For 3-credit Theoretical course – 2 classes.
- For 1-credit LAB/practical course – 1 class.

d. Duration of each class:
- For 3-credit Theoretical course – 1 ½ hours.
- For 1-credit LAB/practical course – 2 hours.

e. Total classes:
- For 3-credit Theoretical course – 28 classes.
- For 1-credit LAB/practical course – 14 classes.

f. Total marks assigned to a course – 100 marks.

The Department of Statistics and Data Science runs two semesters a year and gets 14 weeks to complete the required classes. A Semester End Examination (SEE) shall be held at the end of each Semester. Students shall get two weeks of preparation leave before SEE. The key operational requirements to run the program can be summarized as follow:

Table 1: Basic Operational Requirements

Sl. #	Operational requirements	Master's by Coursework (1 year)	Master's by Mixed Mode (1.5 years)
Requirements to complete the program			
1	Semesters per year	2	2
2	Total semesters required	2	3
Requirements to run a semester-based program			
3	Total class weeks in a semester	14	14
4	Preparation leaves before SEE (in weeks)	3	3
5	Duration of SEE (in weeks)	5	5
6	Semester break (in weeks)	4	4

2. Grading Criteria

The Grading Scale, Grades, Grade Point Average (GPA), Cumulative Grade Point Average (CGPA), Course Withdrawal, Incomplete (I) courses, Retake, Grade Improvement, Dropout, etc. are set as per the JU Examination Ordinance.

Table 2: Grading system: Existing JU and UGC grading system

Numerical Grade	Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete	I	0.00

3. Evaluation System for Theory Courses

The Department of Statistics and Data Science adopts a framework for the assessment of its students as advised in the UGC's OBE guideline. Marks of each course is 100 marks. The assessment pattern of the Department of Statistics and Data Science comprises - Continuous Internal Evaluation (CIE), and Semester End Examination (SEE).

- Continuous Internal Evaluation (CIE) carries – 40 Marks.
- Semester End Examination (SEE) carries – 60 Marks.

Individual students are evaluated based on the following criteria with the following marks distribution:

Table 3: Marks distribution of theory courses with different assessment techniques

Sl. #	Assessment Techniques	Marks (%)
Continuous Internal Evaluation (CIE)		
1	Class Tests	20%
2	Assignment	5%
3	External Participation in Curricular/Co-curricular Activities /Presentation of assignment, etc.	5%
4	(i) Quizzes	5%
	(ii) Attendance	5%
Semester End Examination (SEE)		
5	Semester End Examination	60%
Total		***100%***

3.1 Assessment Pattern

The assessment of students under each course follows the **Outcome Based Evaluation (OBE)** system and in accordance with the **Bloom's Taxonomy** as adopted by the UGC of Bangladesh. Bloom's taxonomy is a hierarchical classification system used to define and distinguish different levels for the students in terms of Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating, as follows:

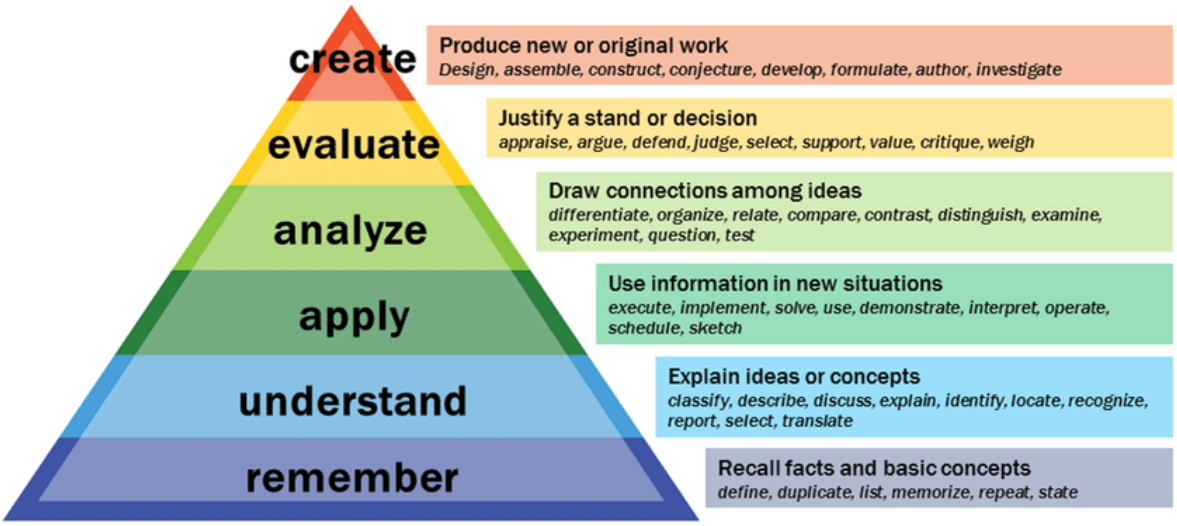

Figure 1: Using Bloom's Taxonomy

3.2 Continuous Internal Evaluation (CIE) for Theory Courses – 40 Marks

The students are continuously evaluated throughout the semester by adopting several assessment methods, e.g., class test, assignment, quizzes /class participation/ attendance and external participation in curricular/co-curricular activities. Each assessment method of CIE follows the following marks distribution in accordance with the Bloom's Taxonomy:

Table 4: Marks distribution for different CIE assessment tools as per Bloom's Taxonomy

Bloom's Category Marks (40)	**Tests (20)**	**Assignments (5)**	**Participation in curricular/ co-curricular activities/presentation (5)**	**Quizzes/ attendance (10)**
Remember				5
Understand		3		5
Apply	5		5	
Analyze	10			
Evaluate	5			
Create		2		

The continuous internal evaluation under each theory course include **minimum** 2 Class tests/Tutorials, 1 Assignment, 2 Quiz and 1 Presentation on external participation in curricular/co-curricular activities/assignments as per the following schedule:

Table 5: Suggested schedule of different assessment tools of CIE

SL#	Evaluation methods	Total unit*	Total Marks	Schedule *
1	Class test/ Tutorial	2	20	• 1st test – after 14th class • 2nd test – after 28th class
2	Assignment	1	5	• Initiate preferably after 16th class
3	Presentation	1	5	• After 25th class (based on assignment, case study, mini survey, mini project, field visit, etc.)
4	Quiz	2	5	• 1st Quiz – before 14th class • 2nd Quiz – before 28th class
	Attendance	-	5	• Shall be calculated as per the 'Marks calculation for class attendance'
Total Marks		**40**		

* If deemed necessary, course teachers can slightly change the schedule of tests/ assignments in consultation with the Chairman of the respective Exam Committee.

Marks calculation for class attendance

The marks obtained by a student in class attendance shall be calculated in proportion to the total number of classes attended by that student, i.e.,

$$\text{Marks in class attendance} = \frac{Number\ of\ classes\ attended\ by\ a\ student}{Total\ number\ of\ classes\ taken\ in\ a\ course} \times Total\ marks\ in\ class\ attendence\ (i.e., 10).$$

Marks in class attendance shall be presented in two decimal places. A student with a class attendance of less than 40% in a particular course will get zero (0) for that course.

Example: Suppose 28 classes were conducted in a course and a student attended 24 classes. Then his/her marks in the class attendance (out of 10) is:

$$\text{Marks in class attendance} = \frac{24}{28} \times 10 = 8.57$$

3.3 Semester End Examination (SEE) for Theory Courses – 60 Marks

Duration of SEE shall be 3 hours. Each assessment method of SEE adopts the following marks distribution in accordance with the Bloom's Taxonomy:

Table 6: Marks distribution of SEE of Theory courses as per Bloom's Taxonomy

Bloom's Category	**SEE (60)**
Remember	10
Understand	10
Apply	15
Analyze	10
Evaluate	10
Create	5
Total Marks	**60**

Questions Pattern for a Theory Course

As per OBE guideline, each course should be evaluated considering six learning levels and thus the question papers of **SEE** should be designed to evaluate student's ability in remembering, understanding, applying, analyzing, evaluating, and creating. Under this circumstance, a question paper for a theory course supposed to consider the following six parts:

- Part A: Questions related to **remembering**,
- Part B: Questions related to **understanding**,
- Part C: Questions related to **applying**,
- Part D: Questions related to **analyzing**,
- Part E: Questions related to **evaluating**, and
- Part F: Questions related to **creating**.

The questions pattern with marks distribution is outlined below:

Table 7: SEE questions pattern for theory courses

Section	**Bloom's Category**	**SEE (60)**	**General instructions**	**Marks**
Part A	Remember	10	Answer any 05 out of 06	5×2.0=10
Part B	Understand	10	Answer any 04 out of 05	4×2.5=10
Part C	Apply	15	Answer any 03 out of 04	3×5.0=15
Part D	Analyze	10	Answer any 02 out of 03	2×5.0=10
Part E	Evaluate	10	Answer any 02 out of 03	2×5.0=10
Part F	Create	5	Answer any 01 out of 02	1×5.0=05
Total Marks		**60**	**-**	**60**

Choosing Appropriate Action Verbs

It is important to use appropriate action verbs for setting questions in the class tests, tutorials, Quiz or even in the semester end examinations. The use of appropriate action verbs facilitates

alignment of program and course learning outcomes and course learning outcomes with assessments. Some examples of appropriate action verbs to be used to assess student's competency at different learning levels are summarized in the table below:

Table 8: Suggested action verbs for questions setting at different learning levels

Learning levels	**Description**	**Suggested action verbs** ***(Start questions with…)***
Level 1: Remembering	Retrieving, recognizing, and recalling relevant knowledge from long-term memory	Define, Count, Draw, Find, Identify, Label, List, Match, Name, Quote, Recall, Recite, Tell, Write
Level 2: Understanding	Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, and explaining	Describe, Discuss, Explain, Give examples of, Conclude, Demonstrate, Identify, Illustrate, Interpret, Predict, Review, Summarize
Level 3: Applying	Carrying out or using a procedure for executing, or implementing	Apply, Calculate, Predict, Solve, Determine, Compute, Execute, Implement, Prepare, Produce, Select, Show, Transfer, Use
Level 4: Analyzing	Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing	Analyze, Characterize, Classify, Compare, Contrast, Differentiate, Discriminate, Distinguish, Debate, Examine, Outline, Relate, Separate, Categorize, Simplify, Associate
Level 5: Evaluating	Making judgments based on criteria and standards through checking and critiquing	Appraise, Argue, Assess, Choose, Conclude, Criticize, Determine, Decide, Evaluate, Judge, Justify, Predict, Prioritize, Prove, Rank, Rate, Relate, Select, Support
Level 6: Creating	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing	Construct, Create, Compose, Design, Derive, Develop, Formulate, Generate, Integrate, Invent, Make, Modify, Organize, Perform, Plan, Produce, Propose, Rewrite

4. Evaluation System for LAB Courses

Marks of each LAB course is 100 marks. Like Theory courses, the assessment pattern of a LAB course also comprises – Continuous Internal Evaluation (CIE), and Semester End Examination (SEE) with the following marks distribution:

- Continuous Internal Evaluation (CIE) carries – 60 Marks.
- Semester End Examination (SEE) carries – 40 Marks.

Individual students shall be evaluated in a LAB course based on the following criteria with the following marks distribution:

Table 9: Marks distribution of LAB courses with different assessment techniques

Sl.#	Assessment Techniques	Marks/ Percentage
Continuous Internal Evaluation (CIE) – 60% marks		
1	LAB tests	20%
2	LAB Report/Assignment / Presentation	10%
3	LAB Participation and Performance/Quiz	20%
4	LAB Attendance	10%
Semester End Examination (SEE) – 40% marks		
5	LAB Final Exam	30%
6	LAB Viva/ In LAB Evaluation	10%
Total		**100%**

4.1 Continuous Internal Evaluation (CIE) for LAB Courses – 60 Marks

The continuous internal evaluation under each LAB course shall include **minimum** 2 LAB tests, 1 Assignment with presentation, Lab performance as per the following schedule:

Table 10: Suggested schedule of different assessment tools of CIE

SL#	Evaluation methods	Total unit	Total Marks	Schedule *
1	LAB test	2	2×10=20	• 1st test – after 7th class • 2nd test – after 14th class
2	Assignment	1	5	• Initiate preferably after 8th class
	Presentation	1	5	• After 12th class (based on assignment, case study, mini survey, mini project, field visit, etc.)
3	LAB Performance	Quiz (2)	2×5=10	• 1st test – before 7th class • 2nd test – before 14th class
		Performance assessment (1)	10	• Performance should be assessed after each LAB class based on completion of the assigned problems/tasks
4	LAB Attendance	-	10	• Shall be calculated as per the 'Marks calculation for class attendance'
Total Marks		**60**		

* If deemed necessary, course teachers can slightly change the schedule of tests/ assignments in consultation with the Chairman of the respective Examination Committee.

4.2 Semester End Examination (SEE) for LAB Courses – 40 Marks

The SEE of a LAB course shall be conducted as per the following modalities:

- Course teacher will prepare question paper for SEE and responsible for evaluating SEE scripts.
- Course teacher and at least two additional faculty members, nominated by the respective exam committee, will be responsible for conducting LAB exam and in LAB evaluation/viva for each course.