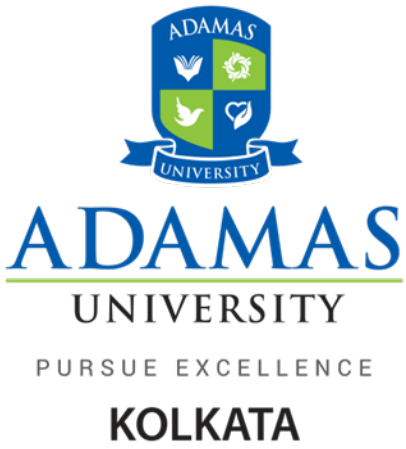

ADAMAS UNIVERSITY

SCHOOL OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS

OBE CURRICULUM AND SYLLABUS OF

B.SC. (HONS) STATISTICS AND DATA ANALYTICS PROGRAMME

ACADEMIC YEAR 2022-23

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF MATHEMATICS

VISION OF THE UNIVERSITY

To be an internationally recognized university through excellence in inter-disciplinary education, research and innovation, preparing socially responsible well-grounded individuals contributing to nation building.

MISSION STATEMENTS OF THE UNIVERSITY

M.S 01: Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology

M.S 02: Foster outcomes-based education system for continuous improvement in education, research and all allied activities

M.S 03: Instill the notion of lifelong learning through culture of research and innovation

M.S 04: Collaborate with industries, research centers and professional bodies to stay relevant and up-to-date

M.S 05: Inculcate ethical principles and develop understanding of environmental and social realities

CHANCELLOR / VICE CHANCELLOR

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF MATHEMATICS

VISION OF THE SCHOOL

To be recognized globally as a provider of education in Basic and Applied Sciences, fundamental and interdisciplinary research.

MISSION STATEMENTS OF THE SCHOOL

M.S 01: Develop solutions for the challenges in sciences through value-based science education.

M.S 02: Conduct research leading to innovation in sciences.

M.S 03: Nurture students into scientifically competent professionals in the usage of modern tools.

M.S 04: Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

DEAN / SCHOOL CONCERNED

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF MATHEMATICS

VISION OF THE DEPARTMENT

To create a center of academic excellence in Mathematics and Statistics through active teaching-learning and collaborative research

MISSION STATEMENTS OF THE DEPARTMENT

M.S 01: Deliver graduates with considerable Mathematical and Statistical skills along with real-world problem-solving ability.

M.S 02: Create a framework to nurture students through outcome-based education towards building a strong foundation in mathematical sciences for academia and industry.

M.S 03: Conduct fundamental and cutting-edge collaborative research on mathematical and interdisciplinary fields.

M.S 04: Contribute towards development of mathematical foundation in pan-university level.

HOD **DEAN / SOBAS**

ADAMAS UNIVERSITY, KOLKATA

SCHOOL OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS

Name of the Programme: B.Sc. (Hons) Statistics and Data Analytics

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

PEO 01: Graduate will equip with latest techniques in Data Analytics like Python, Machine learning, Big Data etc.

PEO 02: Graduates will able to choose their course as a training ground to develop their positive attitude and skills.

PEO 03: Graduates of the program will become technically competent to pursue higher studies.

PEO 04: Graduates are prepared to survive in rapidly changing technology and engage in life-long learning.

PEO 05: Graduates will communicate effectively in both verbal and written form in industry and society.

HOD **DEAN / SOBAS**

ADAMAS UNIVERSITY, KOLKATA

SCHOOL OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS

Name of the Programme: B.Sc. (Hons) Statistics and Data Analytics

GRADUATE ATTRIBUTE / PROGRAMME OUTCOME (PO)

GA 01 / PO 01: Academic Excellence: Understanding the academic field of Statistics and its different learning areas with applications.

GA 02 / PO 02: Contextualized Understanding: Develop the ability to distinguish between random and non-random experiments and simultaneously learn the theory and applications of probability

GA 03 / PO 03: Design/development of solutions: Identify, design and solve scientific problems based on data collection, data interpretation and analysis of results.

GA 04 / PO 04: Conduct investigations of complex problems: Explore various real-life problems and ways to solve them with a reliable solution using various statistical methods and tests.

GA 05 / PO 05: Quantitative Aspects: Learn to apply the tools of the various statistical and mathematical procedures with programming to solve real-life problems involving large data sets.

GA 06 / PO 06: Modernization and Tools Usage: Develop the ability in using modern statistical, mathematical and data analytics tools for design and analysis, and quality control.

GA 07 / PO 07: Societal Implication: Apply statistical methods and tools in societal, demographic, health, business and cultural issues

GA 08 / PO 08: Environment and Sustainability: Understand the tools towards problem solving and applications in biological science, agricultural science, and social sciences

GA 09 / PO 09: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of mathematical and data science.

GA 10 / PO 10: Individual and Team Work: Work effectively as an individual or as a member or leader in undertaking projects, research organizations, industries and multidisciplinary area

GA 11 / PO 11: Communication: Build up communication skills, both written and oral, so as to apply them to write effective reports.

GA 12 / PO12: Life Long Learning: Develop the ability to evaluate theories, methods, principles, and applications of pure and applied Statistics and data science

HOD **DEAN / SOBAS**

ADAMAS UNIVERSITY, KOLKATA
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF MATHEMATICS

Name of the Programme: B.Sc. (Hons) Statistics and Data Analytics

PROGRAMME SPECIFIC OUTCOME (PSO)

PSO 01: Have the versatility to work effectively in a broad range of analytic, scientific, government, financial, health, technical and other positions.

PSO 02: Be familiar with a variety of examples where the knowledge of mathematics or statistics helps to explain the abstract or physical phenomena accurately.

PSO 03: Enhance theoretical rigor with technical skills which prepare students to become globally competitive to enter into a promising professional life in both government and private sector

HOD **DEAN / SOBAS**

MTH11033	Calculus	L	T	P	C
Version 1.0	**Contact Hours - 45**	3	0	0	3
Pre-requisites/Exposure	Class 12 Mathematics				
Co-requisites	--				

Course Objectives:

The objective of this course for the graduate student is:

1. To acquire the knowledge of continuity, and differentiation with various properties and understand their use in various applications.
2. To skill the undergraduate students to compute the various types of integrations, Beta and Gamma functions and its applications.
3. To get familiar and understand as well as learn to apply the various methods of ordinary differential equations.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Build** the concept of limit, continuity, derivatives and maximum and minimum of one and two variables
CO2. **Develop** the knowledge of definite integral, double integral, beta and Gamma function
CO3. **Acquire** the knowledge of first order differential equations
CO4. **Develop** the concept of higher order differential equation and Wronskian, its properties

Course Description:

This course is very important and designed for undergraduate students to get familiar and knowledgeable about the fundamentals and methods of Differential and Integral Calculus, and Differential equations. Only high school level mathematics is needed to understand this course. This is a basic course and it will not only help students to understand the other undergraduate courses also helps to understand the advanced mathematics to be used in the further course of study and higher studies. This course covers theory and methods o limit, continuity, differentiability, maxima and minima, Indefinite and definite integrations, double integrals, Beta, Gamma functions, and its applications in other areas. Also, this course includes the various solution methods of linear and nonlinear ordinary and partial differential equations. Classes will be conducted by audio-video lectures as well as power point presentations. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

Unit I: Differential Calculus [16L]

Review of Limits and continuity, properties of continuous functions, differentiation and its properties, Indeterminate forms: L-Hospital's rule, successive differentiation and Leibnitz rule, Partial derivatives, Euler's theorem on homogeneous functions, total differentiation, Jacobian, Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange multiplier) and its applications

Unit II: Integral Calculus [14L]

Review of integration and definite integral, Differentiation under integral sign, double integral, change of order of integration, transformation of variables, Improper Integration, Beta and Gamma functions: properties and relationship between them.

Unit III: Ordinary Differential Equations [**15L**]

Introduction, order and degree of a differential equation, formation of differential equation, Exact differential equations, Integrating factors, linear differential equation, Bernoulli's form, Higher Order Differential Equations**:** Linear differential equations of order n, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals, Wronskian, its properties and applications.

Text Books

T1. Mukherjee, B. N. & Das, B. C. Key to differential calculus. U N Dhur& Sons.
T2. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.
T3. K. C. Maity and R. K. Ghosh, Differential calculus, an introduction to analysis

Reference Books

R1. Kumar, V. Differential calculus. Mcgraw-Hill.
R2. Lang, S. Calculus of several variables. Springer.
R3. Courant, R. and John, F. Introduction to calculus and analysis, volume II. Springer.
R4. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

Mapping between COs, POs and PSOs:

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Build** the concept of limit, continuity, derivatives and maximum and minimum of one and two variables	PO1, PO2, PO12, PSO1, PSO2
CO2	**Develop** the knowledge of definite integral, double integral, beta and Gamma function	PO1, PO6, PO12, PSO1, PSO2
CO3	**Acquire** the knowledge of first order differential equations	PO1, PO6, PO12, PSO1, PSO2
CO4	**Develop** the concept of higher order differential equation and Wronskian, its properties	PO1, PO6, PO12, PSO1, PSO2

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH11033	Calculus	3	1	-	-	-	2	-	-	-	-	-	3	3	3	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11072	Probability Theory	L	T	P	C
Version 1.0	Contact Hours - 45	3	0	0	3
Pre-requisites/Exposure	12th Level Mathematics and Calculus				
Co-requisites	--				

Course Objectives:

- To give knowledge of basic set theory, relation, and function
- To develop the concept of probability theory, conditional probability and Bayes' theorem and its applications
- To gain fundamental concept of one- and two-dimensional random variables and related properties

Course Outcomes

On completion of this course, the students will be able to

CO1. **Define** the terms related to set theory, relation, mapping, and function
CO2. **Illustrate** the concept of probability, Bayes' theorem and its applications
CO3. **Solve** the problems related to probability theory
CO4. **Build** the fundamental knowledge of one- and two-dimensional random variables and related properties

Course Description:

In this course first, we will discuss the various concept of Set, Relation and mapping as the prerequisites for this course. This course introduces the basic concept of probability theory in one and two-dimensional random variables. This course discusses the conditional probability and application of the Bayes theorem. Also, in this course, two types of random variables i.e. discrete and continuous in single & bivariate random variables with their distribution and density functions will be discussed. It also examines the expectation, dispersion and moments of a random variable. This course deal with two dimensional random variables with several properties.

Course Content:

Unit I: Set, Relation, Mapping and Algebraic Structure [**10L**]

Basic properties of Sets, Set operations, De Morgan's laws, Cartesian product of Sets, Relation, Equivalence Relation, relation between Equivalence Relation and partition, congruence of integers, congruence classes. Mapping: Injection, Surjection, Bijection, Identity and Inverse mappings, composition of mappings and its associativity. Binary operations: Definitions and examples, commutative and associative binary operations, identity and inverse element.

Unit II: Probability **[18L]**

Introduction, Random Experiments, Sample Space, concept of three types of Sample Space – finite, countably infinite and uncountably infinite, Events and Algebra of Events. Definitions of Probability – Classical, Statistical and Axiomatic. Applications.

Laws of Addition and Multiplication, Conditional Probability, theorem of Total Probability, Bayes' theorem and its applications, Independent Events.

Unit III: Random variables **[17L]**

Definition, Discrete and Continuous Random Variables, Cumulative Distribution Function (C.D.F.) and its properties (with proof), Probability Mass Function (P.M.F.) and Probability

Density Function (P.D.F.), Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles.

Two dimensional Random Variables: discrete and continuous type, joint, marginal and conditional distributions, properties of C.D.F., Independence of Random Variables, Theorems on sum and product of Expectations of Random Variables, Conditional Expectation and Variance, Correlation and Regression.

Text Books

T1. M K Sen, Shamik Ghosh, Parthasarathi Mukhopadhyay (2019): Topics in Abstract, 3rd Edn., Universities Press.

T2. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

Reference Books

R1. Goon A.M., Gupta M.K. & Dasgupta B. (2003): An Outline of Statistical Theory, Vol I, The World Press, Kolkata.

R2. Ross S. (2002): A First Course in Probability, Prentice Hall.

R3. Rohatgi V. K. and Saleh A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint), John Wiley and Sons.

R4. Hogg R.V., Tanis E.A. and Rao J.M. (2009): Probability and Statistical Inference, 7th Ed, Pearson Education, New Delhi.

R5. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.

R6. Uspensky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** the terms related to set theory, relation, mapping, and function	PO1, PO2, PO12, PSO2, PSO3
CO2	**Illustrate** the concept of probability, Bayes' theorem and its applications	PO1, PO2, PO3, PO4, PO5 PO12, PSO2, PSO1
CO3	**Solve** the problems related to probability theory	PO1, PO2, PO3, PO4, PO5 PO12, PSO2, PSO1
CO4	**Build** the fundamental knowledge of one- and two-dimensional random variables and related properties	PO1, PO2, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11072	Probability Theory	3	3	3	3	3	-	-	-	-	-	-	3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11001	Descriptive Statistics	L	T	P	C
Version 1.1	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	12th level Mathematics				
Co-requisites	--				

Course Objectives:
To develop the concept of different descriptive measures for quantitative as well as qualitative data.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Demonstrate** tabular and diagrammatic representation of frequency distribution of discrete and continuous data.
CO2. **Illustrate** descriptive measures for univariate data.
CO3. **Illustrate** descriptive measures for bivariate data.
CO4. **Explain** consistency and associations between attributes.

Course Description:
In the present world, we are surrounded by data, and it is important to know how to draw conclusions and make decisions from it. This course is designed to teach students the basic concepts of statistics used to analyse, interpret, and predict outcomes from data. The course first introduces various purposes of statistical analysis and the preliminaries of data distribution and presentation. The course covers the fundamentals concepts, related theorems and problems on measure of central tendency, bivariate data, and analysis of categorical data. This is an efficient beginner course for students interested in further studies on Data Science, Machine Learning, Big Data Analysis, and other relevant fields.

Course Content:

Unit I: Introduction [12L]
Definition and scope of Statistics, concepts of statistical Population and Sample. Data: Quantitative and Qualitative, Discrete and Continuous, Cross-sectional and Time-series, Primary and Secondary. Scales of measurement - Nominal, Ordinal, Interval and Ratio. Presentation of data: tabular and graphical Frequency distributions, cumulative frequency distributions and their graphical representations. Stem and Leaf displays.

Unit II: Univariate Data [18L]
Measures of Central Tendency: Mean, Median, Mode. Measures of Dispersion: Range, Mean deviation, Standard deviation, Quartile deviation, Coefficient of variation. Moments, Skewness and Kurtosis. Sheppard's corrections for Moments. Box Plot and Outliers detection.

Unit III: Bivariate data [18L]
Definition, Scatter diagram, simple Correlation, simple linear Regression, principle of least squares, fitting of Polynomial and Exponential curves, Correlation Ratio, Correlation Index, Intra-class correlation. Rank correlation – Spearman's and Kendall's measures.

Unit IV: Analysis of categorical data [12L]

Theory of attributes, data consistency, Contingency table, independence and association of attributes, Measures of association - Odds ratio, Pearson's and Yule's measure, Goodman-Kruskal gamma.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002) : Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

T2. Yule G.U. and Kendall M.G. (1994) : An Introduction to the theory of Statistics, 14th Edn. Universal Book Stall, Delhi.

Reference Books

R1. Gupta, S. C. & Kapoor, V. K. (1975) : Fundamentals of Mathematical Statistics: A Modern Approach. S. Chand & Company

R2. Nguyen, H. T., & Rogers, G. S. (1989) : Fundamentals of Mathematical Statistics: Probability for Statistics. Springer Science & Business Media.

R3. Agresti, A. (2010) : Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** tabular and diagrammatic representation of frequency distribution of discrete and continuous data.	PO1, PO3, PO4, PO5, PO8, PSO1, PSO3
CO2	**Illustrate** descriptive measures for univariate data.	PO1, PO2, PO3, PO8, PSO1, PSO2
CO3	**Illustrate** descriptive measures for bivariate data.	PO1, PO3, PO4, PO5, PO8, PSO1, PSO3
CO4	**Explain** consistency and associations between attributes.	PO1, PO2, PO5, PSO1, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11001	Descriptive Statistics	3	3	3	3	3	-	-	3	-	-	-	-	3	1	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12002	Descriptive Statistics Practical	L	T	P	C
Version 1.0	Contact Hours - 45	0	0	2	2
Pre-requisites/Exposure	Descriptive Statistics				
Co-requisites	Use of scientific calculators and/or Microsoft Excel				

Course Objectives:
To write codes to calculate descriptive measures for quantitative as well as qualitative data.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Demonstrate** tabular and diagrammatic representation of frequency distribution of Discrete and Continuous data using scientific tools
CO2. **Illustrate** Descriptive measures for Univariate data using scientific tools.
CO3. **Illustrate** Descriptive measures for Bivariate data using scientific tools.
CO4. **Explain** consistency and associations between attributes using scientific tools.

Course Description:
In the present world, we are surrounded by data, and it is important to know how to draw conclusions and make decisions from it. This course is designed to provide students hands on experience to manage, statistically analyse and interpret various real-life data. The course demonstrates the methods of graphically representing data, computing different measures of central tendency, correlation analysis of bivariate data, interpretation of categorical data. The class activities include lectures, hands-on practices, tutorials, assignments, quizzes, and interactions. Moreover, the students will actively participate in discussion and problem solving in class. This is an efficient beginner course for students to build practical skill of statistical data analysis. In addition, this course will enhance the ability of the students to perform better for different governmental and private job opportunities.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or MS Excel)

Sl. No.	Name of the Experiments
1	Diagrammatic representation of data.
2	Problems based on construction of frequency distributions, cumulative frequency distributions and their graphical representations, Stem and Leaf plot.
3	Problems based on measures of Central Tendency.
4	Problems based on measures of Dispersion.
5	Problems based on combined mean and variance and coefficient of variation.
6	Problems based on Moments, Skewness and Kurtosis.
7	Problems related to Quantiles and measures based on them, construction of Box and Whisker plot.
8	Problems based on analysis of Bivariate data.
9	Problems based on measures of Rank Correlation.
10	Problems based on analysis of Categorical data.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

T2. Yule G.U. and Kendall M.G. (1994): An Introduction to the theory of Statistics, 14th Edn. Universal Book Stall, Delhi.

Reference Books

R1. Gupta, S. C. & Kapoor, V. K. (1975): Fundamentals of Mathematical Statistics: A Modern Approach. S. Chand & Company

R2. Nguyen, H. T., & Rogers, G. S. (1989): Fundamentals of Mathematical Statistics: Probability for Statistics. Springer Science & Business Media.

R3. Agresti, A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

Mapping between COs, POs and PSOs:

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** tabular and diagrammatic representation of frequency distribution of Discrete and Continuous data using scientific tools.	PO1, PO3, PO5, PO6, PSO1, PSO3
CO2	**Illustrate** Descriptive measures for Univariate data using scientific tools.	PO1, PO3, PO5, PO6, PSO1, PSO3
CO3	**Illustrate** Descriptive measures for Bivariate data using scientific tools.	PO1, PO3, PO5, PO6, PO7, PO8, PSO1, PSO2, PSO3
CO4	**Explain** consistency and associations between attributes using scientific tools.	PO1, PO3, PO5, PO6, PO7, PSO1, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12002	Descriptive Statistics Practical	3	-	3	-	3	3	2	1	-	-	-	-	3	1	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

ENG11057	English Language and Literature	L	T	P	C
Version 1.0	Contact Hours - 30	2	0	0	2
Pre-requisites/Exposure	Basic Knowledge in English Language and Literature				
Co-requisites	--				

Course Objectives:

1. To introduce the students to applied knowledge of English as a language
2. To give basic idea regarding the day-to-day usage of the language
3. To facilitate the students in various required writing techniques and skills
4. To give them the confidence to express themselves using basic communication skills of English as a language

Course Outcomes:

On completion of this course, the students will be able to

CO1. Explain the ethical use of language at the work space
CO2. Recognizing the importance of language as lifelong process of learning
CO3. Developing the capability to work as a team.
CO4. Identifying their individual language related skills
CO5. Describe and develop the communication skills through speaking, reading and writing
CO6. Building perceptions for accommodating all sorts of opinions

Course Description:

English Language and Literature, is a foundational course for the students to sharpen their reading, writing, and speaking skills, using the language English. It would give them the confidence to speak their mind at a public form using English as the common language of communication and also would help them to perform extravagantly during any job interview on both national and international level. It would also train them in the basic applications of English as a language in their day-to-day lives at both formal and informal front.

Course Content:

Unit I: Communication

a) Types of Communication
b) Verbal and Non-verbal Communication
c) Barriers and Strategies of Communication

Unit II: Grammar and Syntax

a) Subject-verb agreement
b) Conjunction
c) Articles
d) Prepositions
e) Editing
f) Idioms
g) One- Word Substitutions

Unit III: Listening Skills

a) Active Listening
b) Types of Listening
c) Listening Exercises

Unit IV: Speaking Skills

a) Introduction
b) Extempore
c) Group Discussion
d) Mock Interview

Unit V: Writing Skills

a) Composition
b) Paragraph
c) Letter writing- CV and application letter
d) Report Writing
e) Notice writing
f) Business Communication

Unit VI: Reading and Textual analysis

a) Reading Comprehension
b) Interpreting Graphics

Text Books

T1. Spoken English and Functional Grammar. P. C. Das.
T2. Essential Grammar in Use. Raymond Murphy

Reference Books

R1. Kaul Asha. Effective Business Communication. PHI Learning Pvt Ltd. 2014.
R2. Wren and Martin. High School Grammar and Composition. S. Chand, 1995.
R3. Lewis, Norman. Word Power Made Easy. Anchor: 2014.
R4. Riordan, Daniel G & Pauley Steven A.: Technical Report Writing Today. 2004.
R5. Hamp-Lyons and Heasely, B. Study Writing; A Course in Written English. For Academic and Professional Purposes, Cambridge Univ. Press, 2006.
R6. Quirk R., Greenbaum S., Leech G., and Svartik, J. A Comprehensive Grammar of the English language, Longman: London, 1985.
R7. Gupta, A. English Reading Comprehension. Ramesh Publishing House, 2009.
R8. Balasubramaniam, T. A Textbook of English Phonetics for Indian Students. Macmillan: 2012.

R9. A Practical Course in English Pronunciation. J Sethi, Kamlesh Sadanand and D.V. Jindal.
R10. English for Technical Communication. NP Sudarshana and C Savitha.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO-1	Explain the ethical use of language at the work space	PO9
CO-2	Recognizing the importance of language as lifelong process of learning	PO12
CO-3	Developing the capability to work as a team.	PO9
CO-4	Identifying their individual language related skills	PO9
CO-5	Describe and develop the communication skills through speaking, reading and writing	PO10
CO-6	Building perceptions for accommodating all sorts of opinions	PO11

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ENG11057	English Language and Literature	-	-	-	-	-	-	-	-	2	3	1	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11655	Elective Programming Language I	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	10+2 Level Mathematics, Knowledge of Basics of Computer				
Co-requisite	NIL				

Course Objectives:

1. To understand the nature of programming as human activity.
2. To practice the programming construct to solve multi-dimensional problems.
3. To relate and implement mathematical concepts through programming in order to solve computational problems.
4. To enable students to acquire structure and written expression required for their profession.
5. To understand the principles of data storage and manipulation.

Course Outcomes:

On the completion of this course the student will be able to

CO1. **Define** basics concepts of programming structure and implement the basics concepts of programming

CO2. **Solve** and execute various problems using programming language and select the best solution.

CO3. **Apply** modularized solution and design such programs to appraise the solution

CO4. **Illustrate** the basic usage of memory and construct such memory in terms of array in a program.

CO5. **Define** and construct different data structures for various collection of data.

Course Description:

Programming skills are mandatory for designing or solving problems through digital device. It is the language through which computational/digital devices are communicated rather interfaced. To develop any software programming language is a must. In present era almost all aspect of life is somehow largely related to virtualization and digital data/information. Devices from smartphones to other handheld devices, drones, cameras, medical instruments etc. all needs programming at some part. In engineering it has become quintessential for the students/research scholars to learn programming. In this course, students will learn how to solve problems in various domains through a programming language. This course enables students with the basic skills of C Programming Language. Five Different related modules comprise this course. First Unit familiarizes students with basics of computers, algorithmic method to solve problem, introduction to generic programming construct. Basics of C Programming is upto iterative structure is depicted in Unit II. In Unit III students will learn about modularization using functions and one advance concept of C Programming, Pointers. Unit IV will cover one of the most important concepts in C Programming, Array and Strings. Unit V will accomplish this course with the advance concept like Structure, Union and File Handling. After this course students will grow their analytical ability to solve problem and logical skill. Also, this course effectively creates the ability to grasp any other Programming Language in easier manner.

Course Content:

Unit I: [10L]

Basic Concepts of Programming: Introduction to components of a Computer System (disks, memory, processor, where a program is stored and executed, operating systems, compilers, etc.), Idea of Algorithm: steps to solve logical and numerical problems, Representation of Algorithms: Flowchart/Pseudo code with examples, From Algorithms to Programs; source code, variables and memory locations, Syntax and Logical Errors in compilation, Object and Executable code

Unit II: [15L]

Basics of C Programming : Characters used in C, Identifiers, Keywords, Data type & sizes, Constants &Variables, Various Operators used such as Arithmetic Operators, Relational & Logical Operators, Increment & Decrement Operators, Assignment Operators, Conditional or Ternary Operators, Bitwise Operators & Expressions; Standard Input & Output, formatted input scanf( ), formatted output printf( ); Flow of Control, if-else, switch-case, Loop Control Statements, for loop, while loop, do-while loop, nested loop, break, continue, goto, label and exit( ) function

Unit III: [12L]

Functions and Pointers: Definition of Function, Declaration or Prototype of Function, Various types of Functions, Call by Value, Call by Reference, Recursion, Tail Recursion, Definition of Pointer, Declaration of Pointer, Operators used in Pointer, Pointer Arithmetic, Functions with Pointer

Unit IV [15L]

Arrays and String: Definition, Single and Multidimensional Arrays, Representation of Arrays - Row Major Order, and Column Major Order, Application of arrays – searching and sorting, Sparse Matrices and their representations. Definition of a String, Declaration of a String, Initialization of a String, Various String Handling Functions with example

Structures and Unions: Definition of a Structure, Declaration of a Structure & Structure Variable, Initialization of a Structure, Operators used in Structure, Structure within Structures, Union, Difference between a Structure and a Union

Files: Types of File, File Processing, Handling Characters, Handling Integers, Random File Accessing, Errors During File Processing

Unit V [08L]

Overview of Stacks and Queues: Introduction to Stack, Primitive operations on Stack, Real-life applications of Stack, Introduction to Queues, Primitive operations on Queues, Real-life applications of Queues.

Text Books:

1. Balagurusamy, E., n.d. Programming In ANSI C. 5th ed. Bangalore: mcgraw-hill.
2. Gotfreid (1996) Schaum's Outline of Programming with C, 2nd edn., USA: McGraw-Hill
3. Brian W. Kernighan, Dennis Ritchie (1988) C Programming Language, 2nd edn.: Prentice Hall.

Reference Books:

1. Al Kelley, Ira Pohl (1988) *A Book on C*, 4 edn.: Addision Wesley Longman

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** basics concepts of programming structure and implement the basics concepts of programming	PO1, PO6, PO12, PSO3
CO2	**Solve** and execute various problems using programming language and select the best solution.	PO1, PO3, PO6, PO12, PSO2, PSO3
CO3	**Apply** modularized solution and design such programs to appraise the solution	PO1, PO3, PO6, PO12, PSO2, PSO3
CO4	**Illustrate** the basic usage of memory and construct such memory in terms of array in a program.	PO1, PO6, PO12, PSO3
CO5	**Define** and construct different data structures for various collection of data.	PO1, PO3, PO6, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11655	Elective Programming Language I	2	-	2	-	-	3	-	-	-	-	-	3	-	2	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE12656	Elective Programming Language I Lab	L	T	P	C
Version 1.0	Contact Hours – 45 Hours	0	0	3	2
Pre-requisite/Exposure	10+2 Level Mathematics, Knowledge of Basics of Computer				
Co-requisite	NIL				

Course Objectives:

1. To comprehend the practical nature of programming by solving through computer systems.
2. To practice the programming construct to solve multi-dimensional problems.
3. To relate and implement mathematical concepts through programming in order to solve computational problems.
4. To enable students to acquire structure and written expression required for their profession.
5. To understand the principles of data storage and manipulation.

Course Outcomes:

On the completion of this course the student will be able to

CO1. **List** and memorize various Unix commands. Also, students be able to construct various basic programs and appraise them.

CO2. **Design** and execute iterative statement in a program. Also, students be able to differentiate among different iterative structure.

CO3. **Construct** such programs that used to define user defined functions and to design library functions.

CO4. **Develop** array concept in 1-Dimensional and 2-Dimensional construct. Hence be able to design string functions to cater to various character array related problem.

CO5. **Find** the concept of Stack, Queue, and Linked List and appraise them in different cases.

Course Description:

Practical Programming skills are mandatory for designing or solving problems through digital device by implementation. To develop any software the behavior of a programming language is a must through problem solving. In present era almost all aspect of life is somehow largely related to virtualization and digital data/information. Devices from smartphones to other handheld devices, drones, cameras, medical instruments etc. all needs programming at some part. In engineering it has become quintessential for the students/research scholars to learn programming. In this course, students will learn how to solve problems in various domains through a programming language. This course enables students with the basic skills of C Programming Language. Five Different related modules comprise this course. First Unit familiarizes students with basics of computers, algorithmic method to solve problem, introduction to generic programming construct. Basics of C Programming is upto iterative structure is depicted in Unit II. In Unit III students will learn about modularization using functions and one advance concept of C Programming, Pointers. Unit IV will cover one of the most important concepts in C Programming, Array and Strings. Unit V will accomplish this course with the advance concept like Structure, Union and File Handling. After this course students will grow their analytical ability to solve problem and logical skill. Also, this course effectively creates the ability to grasp any other Programming Language in easier manner. In all these modules related programming problems are practiced to understand the syntactical and semantical correctness of a program. Gradually students become more comprehensive through the progress of the course.

Course Content:

List of Experiments:

1. Familiarization with LINUX commands and vi editor.
2. Programs to demonstrate Decision Making, Branching and Looping, Use of break and continue statement etc.
3. Implementation involving the use of Arrays with subscript, String operations and pointers.
4. Implementation involving the use Functions and Recursion.
5. Implementation involving the use Structures and Files.
6. Implementation based on Stack Queues and Linked List for example Insertion and Deletion.

Text Books:

1. Balagurusamy, E., n.d. Programming In ANSI C. 5th ed. Bangalore: McGraw-hill.
2. Gotfreid (196) *Schaum's Outline of Programming with C*, 2nd ed., USA: McGraw-Hill
3. Brian W. Kernighan, Dennis Ritchie (1988) *C Programming Language*, 2nd ed., : Prentice Hall.
4. Das Sumitabha, UNIX Concepts and Applications, 4th Ed., New Delhi, Tata McGraw-Hill

Reference Books:

1. Al Kelley, Ira Pohl (1988) *A Book on C*, 4th ed. Addision Wesley Longman

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**List** and memorize various Unix commands. Also, students be able to construct various basic programs and appraise them.	PO1, PO2, PO3, PO6, PO12, PSO3
CO2	**Design** and execute iterative statement in a program. Also, students be able to differentiate among different iterative structure.	PO1, PO2, PO3, PO5, PO6, PO12, PSO3
CO3	**Construct** such programs that used to define user defined functions and to design library functions.	PO1, PO2, PO3, PO5, PO6, PO12, PSO3
CO4	**Develop** array concept in 1-Dimensional and 2-Dimensional construct. Hence be able to design string functions to cater to various character array related problem.	PO1, PO2, PO3, PO5, PO6, PO12, PSO3
CO5	**Find** the concept of Stack, Queue, and Linked List and appraise them in different cases.	PO1, PO2, PO3, PO6, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE12656	Elective Programming Language I Lab	3	3	3	-	3	3	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CHM11151	ELECTIVE CHEMISTRY I	L	T	P	C
Version 1.0	**CONTACT HOURS- 60**	3	1	0	4
Pre-requisites/Exposure	Physics and Chemistry of class 12 or 10+2 level				
Co-requisites	Partial differentiation, model making, graph plotting				

Course Objectives:

1. To introduce important concepts required in the field of the course elective chemistry. This course gives students a thorough understanding regarding the prerequisites of basic chemistry knowledges in their course curriculums.
2. To introduce clear understanding of energy conditions necessary to execute a feasible chemical reaction.
3. To impart the basic notions of different properties of liquid states of chemical compounds and their effects with atmosphere.
4. To impart the concepts required for kinetics of a reaction mechanism and deeper understanding of the molecular interactions which can influence chemical reactivity. Students can understand the various kinds of reaction mechanisms occurring in their daily life cycle.
5. To learn the basic understanding of atomic structure of molecules important in our daily life and how nuclear reactions are pertinent to their structure.
6. To conceptualize the essence of molecular bonding of necessary molecules.

Course Outcomes:

On completion of this course, the students will be able to

CO1	**Explain** exclusive terminologies associated with thermodynamics and the basic concepts of thermodynamics i.e. heat transfer and its consequences with the thermodynamic system.
CO2	**Understand** the difference between what the molecules are doing in a solid, liquid, and gas, including movement, spacing, and organization, and the physical characteristics of these states.
CO3	**Understand** the properties of solutions that depends on the number of dissolved particles in solution, but not on the identities of the solutes.
CO4	**Learn** the concept of reaction rates, predict products, yields etc.
CO5	**Understand** the concept of using the symbols for protons, neutrons, electrons, positrons, alpha particles, beta particles, and gamma rays
CO6	**Interpret** periodic properties of elements, principles in molecular theory and bonding models to the study of inorganic compound.

Course Description:

This course gives a detailed understanding of the basics of physical and inorganic chemistry required in other disciplines. This course will include expert instructors who will introduce thermodynamics of chemical reaction, colligative properties of liquid states, the structures of nucleus and subatomic particles and their relations with the chemical properties and especially molecular bonding of important molecules of our daily life. All the lectures will be devoted on discussions of elementary concepts and cutting-edge topics, focusing on practical implementation of knowledge. Instructors will conduct theory classes by taking lecture as well as power point presentations, audio visual virtual lab sessions as per requirement of the course. The tutorials and required assignments will acquaint the students with practical problem-solving techniques led by the course coordinator. After finishing this course, students

from different disciplines will strongly grasp the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

Physical Chemistry-I

Unit- 1-Thermodynamics

Thermodynamics: Definition of thermodynamic terms; Concept of heat and work; First law of thermodynamics; Concept of enthalpy (H); Expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes; Concept of standard state, Standard enthalpy changes of physical and chemical transformations: fusion, sublimation, vaporization,-- solution, dilution, neutralization, ionization.; Hess's law of constant heat summation, Second law

of thermodynamics; Heat engine; Carnot cycle and its efficiency; Entropy (S) as a state function. Spontaneous processes; Concept of Free Energy (G and A). **[10L]**

Unit-2-Liquid state:

Liquid States and Viscosity of Fluids: Nature of the liquid state (short range order and long range disorder); Physical properties of liquids; Vapor pressure, Surface tension; Surface energy, General features of fluid flow (streamline flow and turbulent flow); Coefficient of viscosity and their determination. **[4L]**

Unit-3-Colligative properties

Colligative Properties: What are colligative properties? Dependence of colligative properties; Freezing point depression; boiling point elevation, Raoult's Law and Vapor Pressure Lowering ; osmotic pressure. **[6L]**

Unit-4: Chemical kinetics

Chemical kinetics and catalysis: Order and molecularity of reactions; Rate laws and rate equations for first order and second order reactions (differential and integrated forms); Zero order reactions; Determination of order of reactions; Temperature dependence of reaction rate, energy of activation; Catalytic reactions: homogeneous and heterogeneous catalytic reactions. Enzyme catalysis. **[10L]**

Inorganic Chemistry-I

Unit-I: Atomic structure

Extra-nuclear Structure of atoms, Bohr's model. quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many¬, electron atoms, Aufbau principle. **[10L]**

Unit-II: Chemical Periodicity

Classification of elements on the basis of electronic configuration; Positions of hydrogen and noble gases; Atomic and ionic radii; ionization potential; electron affinity; and electronegativity; periodic and group-wise variation of above properties in respect of s- and p-block elements. **[5L]**

Unit-III: Radioactivity and Nuclear Structure of Atoms

Natural radioactivity, group displacement law, law of radioactive decay, half-life of radio elements. Atomic Nucleus: Stability of 'atomic nucleus, nuclear binding energy, Nuclear reactions: fission, fusion, transmutation of elements. **[5L]**

Unit-IV: Chemical Bonding

Ionic Bonding: General characteristics of ionic compounds; Lattice energy; Born Haber cycle. Covalent bonding: General characteristics of covalent compounds; valence-bond approach**,** directional character of covalent bond; hybridization involving s-, p-, d orbitals; multiple bonding; Valence Shell Electron Pair Repulsion (VSEPR) concept; Partial ionic character of covalent bonds; Fajan's rules. Hydrogen bonding and its effect on physical and chemical properties. **[10L]**

References:

1. D. A. McQuarrie and J. D. Simon: Physical Chemistry — A Molecular Approach

2.G. W. Castellan: Physical Chemistry

3. P. W. Atkins: Physical Chemistry

4. J. E Huheey, E. A. Keiter, R. L. Keiter: Inorganic Chemistry (Principle and structure and reactivity).

5. N. N. Greenwood, A. Earnshaw: Chemistry of the Elements

6. D. F. Shriver, P. W. Atkins, C. H. Langford: Inorganic Chemistry

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs)

Mappings between COs and POs		
Course Outcomes (COs)		Mapped POs
CO1	**Explain** exclusive terminologies associated with thermodynamics and the basic concepts of thermodynamics i.e. heat transfer and its consequences with the thermodynamic system.	PSO1, PO1, PO2
CO2	**Understand** the difference between what the molecules are doing in a solid, liquid, and gas, including movement, spacing, and organization, the physical characteristics of these states.	PSO1, PO1, PO4
CO3	**Understand** the properties of solutions that depends on the number of dissolved particles in solution, but not on the identities of the solutes.	PSO1, PO1, PO2, PO7

CO4	**Learn** the concept of reaction rates, predict products, yields etc.	PSO1, PO1, PO5, PO7
CO5	**Understand** the concept of using the symbols for protons, neutrons, electrons, positrons, alpha particles, beta particles, and gamma rays.	PSO3, PO1, PO4, PO7
CO6	**Interpret** periodic properties of elements, principles in molecular theory and bonding models to the study of inorganic compound.	PSO3, PO1, PO3, PO5, PO7

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CHM 11151	ELECTIVE CHEMISTRY I	3	3	3	-	2	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CHM12152	ELECTIVE CHEMISTRY LAB I	L	T	P	C
Version 1.0		0	0	3	2
Pre-requisites/Exposure	Physics and Chemistry of class 12 or 10+2 level				
Co-requisites					

Course Objectives

1. To introduce important concepts required in the field of the practical field of elective chemistry. This course gives students a detailed understanding of lab-based chemistry knowledges in their course curriculums.
2. To introduce hands on training of standard solutions essential in every practical courses.
3. To impart the elementary ideas of physical methods of determination of surface tension, viscosity of organic solvents and acid catalysed hydrolysis of ester.
4. To learn the basic quantitative methods of titration of alkaline mixtures using various indicators.
5. To learn the determination methods of ionization constant of a weak acid by conductometric method.
6. To introduce the pH metric determination procedure of neutralization of acid-base titration.
7. To impart the determination method for rate constant of decomposition of H2O2 by acidified KI solution using clock reactions.

Course Outcomes:

On completion of this course, the students will be able to

CO1	Develop skills in the proper handling of apparatus and chemicals.
CO2	Develop experimental skill of quantitative volumetric analysis and determination of physical properties of substances.
CO3	Develop skills in the determinant of the concentration or the mass of the minimum formula from the titrated chemical material composing a pure liquid or a solution.

Course Description:

This course gives a detailed understanding of the basics of chemistry lab techniques required in other disciplines. This course will include expert instructors who will introduce a detailed description of lab-based chemistry knowledges in their course curriculums, methods of determination of surface tension and viscosity of common liquids, correlation of theories of kinetics in the light of acid catalysed hydrolysis of ester, different quantitative methods of acid-base titrations using direct and pH mediated methods, determination of ionization constants of weak acids by conductometric titration and clock reaction mediated rate constant determinations. All the lectures will be devoted on discussions of elementary concepts and cutting-edge topics, focusing on practical implementation of knowledge. Instructors will conduct demonstration classes by taking lecture followed by practical hands-on training per requirement of the course. The tutorials and required assignments will acquaint the students with practical problem-solving techniques led by the course coordinator. After finishing this course, students from different disciplines will strongly acquire the hands-on training via experiencing practical lab sessions with the coordinator.

Course Content:

General Chemistry Lab:

Preparation of Solution: Normal Solution; Molar Solution

Determination of surface tension of a given solution by drop weight method using a stalagmometer, considering aqueous solutions of NaCl, acetic acid, ethanol etc, as systems.

Determination of viscosity of organic solvents with Ostwald Viscometer at room temperature.

To determine the rate constant for the acid catalysed hydrolysis of an ester.

Inorganic Chemistry Lab:

Titration of Na4CO3 + NaHCO3 mixture vs HCl using phenolphthalein and methyl orange indicators.

Determination of ionization constant of a weak acid by conductometric method

Determination of neutralization point of the reaction between HC1 and NaOH with the help of pH meter .

Determination of rate constant of decomposition of H202 by acidified KI solution using clock reactions.

References:

1. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency

2. Handbook of Inorganic Analysis (First Edition): U.N Dhur & Sons Private Ltd.

3. Das, S.C. Advanced Practical Chemistry.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Class Assessment	End Term
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs)

Mappings between COs and POs		
Course Outcomes (COs)		**Mapped POs**
CO1	Develop skills in the proper handling of apparatus and chemicals and preparation of standard solutions which are perquisite in respective course curriculum.	PSO1, PO3, PO4
CO2	Develop experimental skill of quantitative volumetric analysis and determination of physical properties of substances.	PSO1, PSO3, PO1, PO2, PO3

CO3	Develop skills in the determination of the concentration or the mass of the minimum formula from the titrated chemical material composing a pure liquid or a solution.	PSO1, PSO3, PO1, PO2, PO3, PO4

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CHM 12152	ELECTIVE CHEMISTRY LAB I	3	3	3	-	2	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

Course Code: DGS11001	DESIGN THINKING	L	T	P	C
Version 1.0		2	0	0	2
Pre-requisites/Exposure	Knowledge of analyzing society problems and product usage problems and a zeal to improve the current situation, in addition to knowing to using laptop/computers, internet, social media interaction, file sharing and uploading, email and communication etiquettes.				
Co-requisites	--				

Course Objectives:

1. To enable students to acquire knowledge, imagination and be more assertive on opinions on problems in society.
2. To enable students to learn basics of research, data collection, analysis, brainstorming to find solutions to issues.
3. To make them understand Design Thinking methodologies to problems in field of study and other areas as well.
4. To help students to understand future Engineering positions with scope of understanding dynamics of working between inter departments of a typical OEM.

Course Outcomes:

On completion of this course, the students will be able to

CO1. Examine design thinking concepts and principles
CO2. Practice the methods, processes, and tools of design thinking
CO3. Apply the Design Thinking approach and model to real world scenarios
CO4. Analyze the role of primary and secondary research in the discovery stage of design thinking

Course Description:

Design thinking course is a completely online course offered to the first year UG programs across all streams. This course is designed to help understand the steps followed in the process of designing a solution to a problem.

Course Content:

UNIT I: WHAT IS DESIGN THINKING [02L]

Designers seek to transform problems into opportunities. Through collaboration, teamwork, and creativity, they investigate user needs and desires on the way to developing human-centered products and/or services. This approach is at the very heart of design thinking.

UNIT II: THE DESIGN THINKING MODEL [02L]

A tool that helps guide you along a design thinking path. The model does this by providing a series of activities that that will help you effectively design a product, service or solution to a user's need. The model presents the approach as a process, allowing us to look at each step – or phase – along the journey to the development of a final design.

UNIT III: PHASE 1: DISCOVER [04L]

Begin the design thinking process with the Discover phase, where you will identify the specific problem your design is intended to solve, as well as important usability aspects from those who will use your design. Discovery can be performed through a variety of different research methods which you will learn in this module.

UNIT IV: PHASE 2: DEFINE [04L]

In the Define phase, you come to understand the problem. We often refer to this as framing the problem. You can do this by using a variety of tools, including storytelling, storyboarding, customer journey maps, personas, scenarios, and more.

UNIT V: PHASE 3: DEVELOP [04L]

Turn your attention to solving the problem. In this phase you brainstorm custom creative solutions to the problems previously identified and framed. To do this, you conceptualize in any way that helps, putting ideas on paper, on a computer, or anywhere whereby they can be considered and discussed.

UNIT VI: PHASE 4: DELIVER [04L]

This phase is all about testing and building concepts. Here you take all of the ideas that have been discussed to this point and bring them a little closer to reality by building a concept; something that makes it easier for a user to experience a design. This concept is referred to as a prototype.

UNIT VII: PHASE 5: ITERATE [04L]

You will test the prototype of your design solution, collecting and acting on feedback received. These actions may mean minor or major revisions to your design, and are repeated as often as necessary until a solution is reached. Tools such as focus groups and questionnaires are used to help you collect feedback that can help with your final design.

UNIT VIII: BEYOND DESIGN THINKING [02L]

The Design Thinking Model is a tool that helps guide you along a design thinking path. The model does this by providing a series of activities that that will help you effectively design a product, service or solution to a user's need. The model presents the approach as a process, allowing us to look at each step – or phase – along the journey to the development of a final design.

Text Books

1. All the references are available to download in the online course.

Reference Books

1. Brown, Tim. "What We Can Learn from Barn Raisers." Design Thinking: Thoughts by Tim Brown. Design Thinking, 16 January 2015. Web. 9 July 2015.
2. Knapp, Jake. "The 8 Steps to Creating a Great Storyboard." Co.Design. Fast Company & Inc., 21 Dec. 2013. Web. 9 July 2015.

3. van der Lelie, Corrie. “The Value of Storyboards in the Product Design Process.” Journal of Personal and Ubiquitous Computing 10.203 (2006): 159–162. Web. 9 July 2015. [PDF].
4. Millenson, Alisson. “Design Research 101: Prototyping Your Service with a Storyboard.” Peer Insight. Peer Insight, 31 May 2013. Web. 9 July 2015.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Examine design thinking concepts and principles	PO1, PO11
CO2	Practice the methods, processes, and tools of design thinking	PO1, PO2
CO3	Apply the Design Thinking approach and model to real world scenarios	PO1, PO2
CO4	Analyze the role of primary and secondary research in the discovery stage of design thinking	PO1, PO5

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
DGS11001	DESIGN THINKING	3	2	-	-	2	-	-	-	-	-	2	-	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11073	Probability Distributions	L	T	P	C
Version 1.0	Contact Hours - 45	2	1	0	3
Pre-requisites/Exposure	Probability Theory				
Co-requisites	--				

Course Objectives:

- To understand the concept of different Generating Functions and Limit Laws
- To build the knowledge of different Discrete Probability Distributions and their applications
- To build the knowledge of different Continuous Probability Distributions and their applications

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Develop** the concepts of different Generating Functions and their applications.
CO2. **Apply** the concepts of different Probability Inequalities, different modes of Convergence, Weak Law of Large Numbers and Central Limit Theorem.
CO3. **Develop** the concepts of different Discrete Probability Distributions with their properties and applications.
CO4. **Develop** the concepts of different Continuous Probability Distributions with their properties and applications.

Course Description:
This course deals with probability and moment generating function, characteristic function, Markov's and Chebyshev's inequalities, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem and discrete and continuous probability distributions and its applications in science and engineering. After successful completion of this course a student will be able to analyse the different applications of probability and probability distributions in real world.

Course Content:

Unit I: Generating Functions and Limit Laws [15L]
Probability Generating Function (P.G.F.), Moment Generating Function (M.G.F.), Cumulant Generating Function and Characteristic Function, Uniqueness and Inversion theorems (without proof) along with applications.
Markov's and Chebyshev's Inequalities, Applications, Sequence of random variables, Convergence in Probability, Convergence in Mean Square and Convergence in Distribution and their interrelations, Weak Law of Large Numbers and their applications, De-Moivre Laplace Limit theorem, Statement of Central Limit Theorem (C.L.T.) for i.i.d. variates, applications of C.L.T.

Unit II: Standard Discrete Probability Distributions [15L]
Uniform, Bernoulli, Binomial, Hypergeometric, Poisson, Geometric, Negative Binomial along with their important properties and applications. Limiting/approximation cases. Truncated distributions. Trinomial distribution and its important properties.

Unit III: Standard Continuous Probability Distributions [15L]
Rectangular, Normal, Lognormal, Exponential, Gamma, Beta, Cauchy, Logistic, Double Exponential and Pareto along with their important properties and applications. Limiting

/approximation cases. Truncated distributions. Bivariate Normal Distribution (BVN): p.d.f. of BVN, important properties of BVN, marginal and conditional p.d.f. of BVN.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.

T2. Goon A.M., Gupta M.K. & Dasgupta B. (2003): An Outline of Statistical Theory, Vol I, The World Press, Kolkata.

T3. Ross S. (2002): A First Course in Probability, Prentice Hall.

Reference Books

R1. Rohatgi V. K. and Saleh A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint), John Wiley and Sons.

R2. Hogg R.V., Tanis E.A. and Rao J.M. (2009): Probability and Statistical Inference, 7th Ed, Pearson Education, New Delhi.

R3. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.

R4. Uspensky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Develop** the concepts of different Generating Functions and their applications.	PO1, PO2, PO3, PO5, PO12, PSO1, PSO2, PSO3
CO2	**Apply** the concepts of different Probability Inequalities, different modes of Convergence, Weak Law of Large Numbers and Central Limit Theorem.	PO1, PO2, PO3, PO4, PO5, PO12, PSO1, PSO2, PSO3
CO3	**Develop** the concepts of different Discrete Probability Distributions with their properties and applications.	PO1, PO2, PO3, PO5, PO12, PSO1, PSO2, PSO3
CO4	**Develop** the concepts of different Continuous Probability Distributions with their properties and applications.	PO1, PO2, PO3, PO5, PO12, PSO1, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11073	Probability Distributions	3	3	3	2	3	-	-	-	-	-	-	3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12074	Probability Distributions Practical	L	T	P	C
Version 1.0	**Contact Hours - 45**	0	0	3	2
Pre-requisites/Exposure	Probability Theory				
Co-requisites	--				

Course Objectives:

- To develop the capability of the students for practical understanding of fundamental aspects of Probability distributions.
- To give students experimental/laboratory-based background, the key prerequisite for performing research near future.
- To build up real-time idea on expectation, variance of different probability distributions, applications of Binomial, Poisson, Negative binomial, Normal distributions and Fitting of different distributions when parameter(s) is/are given and not given.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Develop** the skill to calculate expectation, variance and moments of a given probability distribution.

CO2. **Estimate** the expected frequencies and applications of Binomial, Poisson, Negative Binomial and other discrete distributions.

CO3. **Develop** the practical understanding of area property of Normal distribution and its applications along with the fitting of it.

CO4. **Develop** the practical understanding of the applications of other Continuous distributions.

Course Description:

This course will help the students to develop the skill of calculating the various statistical measures of a given probability distribution. Also, it deals with the different applications and fitting of discrete and continuous probability distributions. After successful completion of this course a student will be able to apply the different probability distributions to real life datasets.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or MS Excel)

Sl. No.	Name of the Experiments
1	Fitting of Binomial distribution for given ‘n’ and ‘p’.
2	Fitting of Binomial distribution after computing mean and variance.
3	Fitting of Poisson distribution for given value of parameter or mean
4	Fitting of Poisson distributions after computing mean.
5	Fitting of Negative Binomial distribution.
6	Fitting of suitable Discrete distributions.
7	Application problems based on Binomial distribution.
8	Application problems based on Poisson distribution.
9	Application problems based on Negative Binomial distribution.
10	Problems based on area property of Normal distribution.
11	To find the ordinate for a given area for Normal distribution.
12	Application based problems using Normal distribution.

13 Fitting of Normal distribution when parameters are given.
14 Fitting of Normal distribution when parameters are not given.
15 Fitting and application-based problems of some other Continuous distributions.
16 Application based Problems on Trinomial distribution.
17 Application based Problems on Bivariate Normal distribution.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
T2. Goon A.M., Gupta M.K. & Dasgupta B. (2003): An Outline of Statistical Theory, Vol I, The World Press, Kolkata.
T3. Ross S. (2002): A First Course in Probability, Prentice Hall.

Reference Books

R1. Rohatgi V. K. and Saleh A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint), John Wiley and Sons.
R2. Hogg R.V., Tanis E.A. and Rao J.M. (2009): Probability and Statistical Inference, 7th Ed, Pearson Education, New Delhi.
R3. Feller W. (1968): An Introduction to Probability Theory & its Applications, John Wiley.
R4. Uspensky J.V. (1937): Introduction to Mathematical Probability, McGraw Hill.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Develop** the skill to calculate expectation, variance and moments of a given probability distribution.	PO1, PO2, PO3, PO4, PO5, PO12, PSO2, PSO3
CO2	**Estimate** the expected frequencies and applications of Binomial, Poisson, Negative Binomial and other discrete distributions.	PO1, PO2, PO3, PO4, PO5, PO12, PSO2, PSO3
CO3	**Develop** the practical understanding of area property of Normal distribution and its applications along with the fitting of it.	PO1, PO2, PO3, PO4, PO5, PO12, PSO2, PSO3
CO4	**Develop** the practical understanding of the applications of other Continuous distributions.	PO1, PO2, PO3, PO4, PO5, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12074	Probability Distributions Practical	3	3	3	3	3	-	-	-	-	-	-	3	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11034	Real Analysis	L	T	P	C
Version 1.1	Contact Hours - 45	3	0	0	3
Pre-requisites/Exposure	$10+2^{th}$ level Mathematics				
Co-requisites	--				

Course Objectives:
To develop the concept of real numbers and its various properties including the concept of sequence and series.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Define** the completeness and Archimedean property of real numbers.
CO2. **Define** the concept of countability and uncountability for the set of real numbers.
CO3. **Illustrate** the concept of open set, closed set and limit point for the set of real numbers.
CO4. **Extend** the idea of convergence of infinite sequences and series through various convergence test.

Course Description:

This course is intended to provide the basic idea of real numbers and its basic properties. Furthermore, many basic properties of real line such as completeness property, Archimedean property. Concepts of the open set, closed set and derived set concept and related results will be discussed in this course. Also, an idea about bounded, convergent, divergent, Cauchy and monotonic sequences and calculation of their limits.is provided through this course.

Course Content:

Unit-I **[15L]**
Real number system: Intuitive idea of numbers, mathematical operations revisited with their properties. Sets and functions: definition and properties Field Axioms: concept of ordered field, bounded set, l.u.b. (supremum) and g.l.b. (infimum) of a set, properties of l.u.b. and g.l.b. of sum of two sets and scalar multiple of a set, least upper bound axiom or completeness axiom. Characterization of IR as a complete ordered field, definition of an Archimedean ordered field, Archimedean property of IR, Q is Archimedean ordered field but not ordered complete.

Unit-II [**10L**]
Sets in $\mathbb{R}$**:** Countable, Uncountable sets and Uncountability of $\mathbb{R}$**.** Intervals, the neighborhood of a point, interior point, open set, union, intersection of open sets, every open set can be expressed as disjoint union of open intervals, limit point and isolated point of a set, criteria for l.u.b. and g.l.b. of a bounded set to be limit point of the set, Bolzano- Weierstrass theorem on limit point.

Unit-III **[20L]**
Sequences and Series of real numbers: Definition of a sequence as function from IN to IR, bounded sequence, convergence and non-convergence, examples, every convergent sequence is bounded and limit is unique, algebra of limits, relation between the limit point of a set and the limit of a convergent sequence of distinct elements, monotone sequences and their convergence. Infinite series: Cauchy convergence criterion for series, positive term series, geometric series, comparison test, the convergence of p-series, Root test, Ratio test, alternating

series, Leibnitz's test(Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.

Text Books:

T1. S.K. Mapa, Introduction to Real Analysis, 7th Edition, Sarat Publishers, India.

T2. S.C. Malik and S Arora, Mathematical Analysis, New Age International Private Limited.

Reference Books:

R1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore.

R2. R.K. Ghosh and K.C Maity, An Introduction to Analysis: Differential Calculus: Part I.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** the completeness and Archimedean property of real numbers.	PO1, PSO2, PSO3
CO2	**Define** the concept of countability and uncountability for the set of real numbers.	PO1, PSO2, PSO3
CO3	**Illustrate** the concept of open set, closed set and limit point for the set of real numbers.	PO1, PSO2, PSO3
CO4	**Extend** the idea of convergence of infinite sequences and series through various convergence test.	PO1, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH11034	Real Analysis	3	-	-	-	-	-	-	-	-	-	-	-	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11080	Linear Algebra	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Prior knowledge of set theory				
Co-requisites	--				

Course Objectives:

- To help the students to acquire the knowledge of vector spaces, linear independence, span, and basis
- To help the students to acquire the knowledge of matrix theory
- To enable the students to evaluate determinant of a square matrix
- To give knowledge of elementary row operations on a matrix
- To help the students to understand the concepts of rank of a matrix and eigenvalue and eigenvector of a square matrix.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Define** real vector spaces, subspaces and develop the idea of linear independence, span and basis
CO2. **Define** matrix including matrix operations, inverses, determinants and rank of a matrix
CO3. **Find** the rank of a matrix along the concept of echelon matrix
CO4. **Extend** the knowledge of Matrix polynomial, Characteristic equation, eigenvalues and eigenvectors and use them in applications.

Course Description:

This course is intended to provide some basic ideas of vector space and it's subspaces. The notions of basis and dimension of a space are also introduced in this course. The tools for performing basic operations on matrices and the use of those tools for solving system of linear equations and matrix equations are there in the course. Furthermore, the concept of determinant and related properties are there in details. Concepts of eigen values and eigen vectors of a matrix and their applications in real world will be discussed in this course.

Course Content:

Unit I **[24L]**

Binary operations, basic group theory with simple properties and examples.
Definitions and examples of vector spaces, subspaces, algebra of subspaces, linear combination of vectors, linear span, generators of vector space, linear independence, basis and dimension, replacement theorem, extension theorem, deletion theorem, extraction of basis, dimension of a vector space, finite-dimensional vector space, dimension of subspaces.

Unit II **[16L]**

Matrices of real and complex numbers, algebra of matrices, symmetric and skew-symmetric matrices. Hermitian and skew-Hermitian matrices, orthogonal matrices, definition & basic properties of determinants, minors and cofactors, Laplace's method, Vandermonde's determinant, symmetric and skew-symmetric determinants. (No proof of theorems), adjoint of a square matrix, invertible matrix, non-singular matrix, the inverse of an orthogonal matrix.

Unit III **[20L]**

Elementary operations on matrices, echelon matrix, rank of a matrix, determination of rank of a matrix, elementary matrices, statements and application of results on elementary matrices.

Generalized inverse (concept with illustrations), Partitioning of matrices and simple properties, characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem.

Text Books

T1. Fraleigh, J. B., A First Course in Abstract Algebra, 7th Ed. Pearson, 2002.
T2. Ghosh and Chakroborty, Higher algebra U N Dhur & Sons.
T3. S. K. Mapa, Higher Algebra- Abstract and Linear, revised Ninth Edition, Sarat Book House, 2003.

Reference Books

R1. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
R2. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint), 2002.
R3. Artin, M., Abstract Algebra, 2nd Ed. Pearson, 2011.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** real vector spaces, subspaces and develop the idea of linear independence, span and basis	PO1, PO2, PO12, PSO1, PSO2, PSO3
CO2	**Define** matrix including matrix operations, inverses, determinants and rank of a matrix	PO1, PO2, PO12, PSO1, PSO2, PSO3
CO3	**Find** the rank of a matrix along the concept of echelon matrix	PO1, PO2, PO12, PSO1, PSO2, PSO3
CO4	**Extend** the knowledge of Matrix polynomial, Characteristic equation, eigenvalues and eigenvectors and use them in applications.	PO1, PO2, PO12, PSO1, PSO2, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH11080	Linear Algebra	3	3	-	-	-	-	-	-	-	-	-	3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

EVS11112	ENVIRONMENTAL SCIENCE	L	T	P	C
Version 1.1	**Contact Hours – 30**	2	0	0	2
Pre-requisites/Exposure	Basic physics, chemistry, biology and mathematics				
Co-requisites	--				
Academic year					

Course Objectives

1. To understand the intrinsic relation between humans and environment, our position in the ecosystem around us
2. To comprehend the significance of the biodiversity surrounding us.
3. To figure out the importance and need for energy resources, various sources of energy, renewable and non-renewable sources, conventional and unconventional sources.
4. To have basic concepts about sustainability, our dependence on nature and the consequences of overexploitation.
5. To enable students to appreciate the importance and how much we owe to the earth systems for our survival.
6. To have a basic concept about the types of pollution and mitigation procedures.
7. To have an overall idea about the environmental legal framework in our country and about the EIA and environmental audit procedures.

Course Outcomes

On completion of this course, the students will be able to

CO1	Relate to multidimensional complex nature of environmental problems, various types of ecosystems, ecosystem dynamics, perceive and appreciate the surrounding nature.
CO2	Perceive with the intrinsic relation between humans and environment, our position in the ecosystem around us, and importance of biodiversity.
CO3	Classify the presence of various pollutants, their significance, and impacts, and develop the underlying concepts involved in various air pollution prevention and mitigation measures.
CO4	Summarise the routes of generation, classification, management, and environmental significance of solid waste.
CO5	Illustrate water chemistry, deduce the relationship between various water pollutants, and understand the principles of various water and wastewater treatment procedures.
CO6	Create awareness and concern about importance of environmental resources and their damage and protection.
CO7	Compare the different approaches and practices of biodiversity conservation and management.
CO8	Explain the legal framework in our country for safeguarding the environment including pollution prevention, control, management, and wildlife management.
CO9	Defend as responsible citizens for various global environmental issues and motivate others for active participation in minimizing the environmental damage already caused.

Course Description:

To distinguish between various types of ecosystems, ecosystem dynamics, perceive and appreciate the surrounding nature and feel connected, develop the concept of innate relationship of humans and biodiversity, need for conservation and different conservation strategies. The students will be developed in a way so that they can spontaneously comprehend the importance of studying about the various air pollutants, their significance and impacts, and develop the underlying concepts involved in various air pollution prevention and mitigation measures, understand fundamental water chemistry, deduce the relationship between various water pollutants, and understand the principles of various water and wastewater treatment procedures. They will understand the routes of generation, classification, management and environmental significance of solid waste, apply the basic concepts of waste management in their daily lives, and understand the need of the 5Rs of waste management, importance of waste minimization.

Course Content:

Unit I:

Multidisciplinary nature of environmental sciences; scope and importance; need for public awareness; concept of sustainability and sustainable development
Forest resources: Function of forests, cause and effects of deforestation, case studies.
Water resources: distribution of water, hydrological cycle, use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems
Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies
Food Resources: World food problems and environmental concern, Food security, case studies
Energy resources: Concept of energy, SI Units of Work, Heat and Power, World energy use, Energy consumption pattern in India and U.S., Environmental aspects of energy utilization Renewable and non-renewable sources; Fossil fuel: types, use and environmental impacts, Solar energy: Solar Radiation – Passive and active solar systems – Flat Plate and Concentrating Collectors – Solar direct Thermal Application– Fundamentals of Solar Photo Voltaic Conversion- advantages and disadvantages of Solar Power generation, Solar energy status in India; Wind Energy: site selection, Wind turbine: basic working principle and types, Wind energy status in India, advantages and disadvantages of Wind Power generation; Hydroelectric power : How is it generated, advantages and disadvantages; Biomass energy: various types, generations of biofuel, Biogas plants, Bio diesel; Geothermal Energy: source, advantages and disadvantages, Nuclear Power: nuclear fission, moderation of reaction, nuclear reactor: pressurized water reactor, advantages and disadvantages **[5 L]**

Unit II: Ecosystems

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Food chains, food webs and ecological pyramids, energy flow, ecological succession. **[5 L]**

Unit III: Biodiversity and its conservation

Levels of Biodiversity: genetic, species and ecosystem diversity. Biogeographical classification of India, Values of biodiversity, Biodiversity at global, National and local levels,

India as a mega-diversity nation, Biodiversity hotspots, Threats to Biodiversity, In-situ and Ex-situ conservation of Biodiversity. **[5 L]**

Unit – IV: Environmental Pollution and Waste Management

Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution, marine pollution; case studies. Nuclear hazards and human health risks.

Sources and generation of solid wastes, their characterization, chemical composition and classification. Different methods of disposal and management of solid wastes (Hospital Wastes and Hazardous Wastes) Recycling of waste material. Waste minimization technologies. Hazardous Wastes Management and Handling Rules, 1989. **[10 L]**

Unit – V: Global Issues and Environmental Acts

Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents.

Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). **[5 L]**

References:

1. Principles of Environmental Science, 4th edition by Cunningham, W.P. and Cunningham, M.A. (2002), Tata McGraw-Hill Publishing Company, New Delhi

2. Basic Environmental Engineering & Elementary Biology by Monidranath Patra and Rahul Kumar Singha, Aryan Publishing house

3. Introduction to Environmental Engineering and Science, by Masters, G.M., Prentice Hall of India, Second Indian Reprint.

4. Wastewater Engineering: Treatment and Reuse, 4th Edition, Metcalf and Eddy, Inc. McGraw-Hill, Inc., New York, 2002

5. Environmental Engineering", Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, McGraw-Hill Education (India) Private Limited, New Delhi

6. Introduction to Environmental Engineering, 2nd Ed. by Davis, M. L. and Cornwell D. A. McGraw Hill, Singapore.

7. Environmental Sciences: The Environment and Human Impact by Jackson, A.R.W. and Jackson, J.M., Longman Publishers

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid Term	Class Assessment	End Term
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

	Mappings between COs and POs	
	Course Outcomes (COs)	**Mapped POs**
CO1	Relate to multidimensional complex nature of environmental problems, various types of ecosystems, ecosystem dynamics, perceive and appreciate the surrounding nature.	**PO6, PO7**
CO2	Perceive the intrinsic relation between humans and environment, our position in the ecosystem around us, and importance of biodiversity.	**PO7, PO8**
CO3	Classify the presence of various air pollutants, their significance, and impacts, and develop the underlying concepts involved in various air pollution prevention and mitigation measures.	**PO3, PO6, PO7**
CO4	Summarise the routes of generation, classification, management, and environmental significance of solid waste.	**PO3, PO6, PO7**
CO5	Illustrate water chemistry, deduce the relationship between various water pollutants, and understand the principles of various water and wastewater treatment procedures.	**PO3, PO6, PO7, PSO3**
CO6	Create awareness and concern about importance of environmental resources and their damage and protection.	**PO8, PO12, PSO3**
CO7	Compare the different approaches and practices of biodiversity conservation and management.	**PO2, PO7, PO8**
CO8	Explain the legal framework in our country for safeguarding the environment including pollution prevention, control, management, and wildlife management.	**PO6, PO8**
CO9	Defend as responsible citizens for various global environmental issues and motivate others for active participation in minimizing the environmental damage already caused.	**PO1, PO2, PO3, PO6, PO8**

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EVS11112	Environmental Science	1	1	1	-	-	3	3	2	-	-	-	1	-	-	1

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11657	Elective Programming Language II	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	10+2 Level Mathematics, Knowledge of Basics of Computer				
Co-requisite	NIL				

Course Objectives:

Students will be motivated to solve the problems in engineering using the concepts of object-oriented programming.

Course Outcomes:

On the completion of this course the student will be able to

CO1. Define Abstraction in all forms and in a holistic way
CO2. Illustrate object-oriented modelling techniques like classes and Instances modelling techniques
CO3. Solve programs using standard design patterns
CO4. Interpret fundamentals of object-oriented programming in Java, including defining Classes, invoking methods, using class libraries, etc.
CO5. Construct programming solutions with exception handling and multi-threading concept
CO6. Solve GUI program with proper event handling techniques

Course Description:

This course investigates object-oriented methods including object-oriented programming methodologies and techniques. Current methodology is emphasized. The use of object-oriented features such as encapsulation, information hiding, inheritance and polymorphism is reinforced by class assignments and programming exercises. The importance of multi-threading and exception handling is introduced in this course.

Course Content:

Unit I: [12L]

OOP Concepts - Data Abstraction, Encapsulation, Inheritance, Benefits of Inheritance, Polymorphism, Classes and Objects, Procedural and OOP Paradigms. Introduction To Java, Data Types, Variables & Constants, Scope & Life Time Of Variables, Precedence Of Operator, Expressions, Type Casting, Enumerated Types, Block Scope, Control Flow, Conditional Statements, Loops, Break & Continue Statements, Arrays, Console Input/Output, Formatting Output, Constructors Methods, Parameter Passing, Static Fields & Methods, Access Control, "This" Reference, Method Overloading, Recursion, Garbage Collection, Building Strings, String Class.

Unit II: [12L]

Inheritance - Hierarchical Inheritance: Super And Sub Classes, Member Accessing Rules, Super Keyword, And Preventing Inheritance: Final Classes And Methods, Object Class And Its Methods.

Polymorphism - Dynamic Binding, Method Overriding, Abstract Classes and Methods

Interfaces - Interfaces and Abstract Classes, Definition, Implementation, Accessing Implementations by Interface References, Extending Interfaces.

Inner Classes - Usage, Local, Anonymous and Static Inner Classes, Examples.
Packages - Definition, Creation And Accessing A Package, Understanding CLASSPATH, Importing Packages.

Unit III: [12L]
Exception Handling - Dealing With Errors, Advantages Of Exception Handling, The Classification - Exception Hierarchy, Checked And Unchecked Exceptions, Try, Catch, Throw, Throws And Finally, Exceptions-Throwing, Exception Specification, Built In Exceptions, Creating Exception Sub Classes.

Multithreading - Difference Between Multiple Processes And Multiple Threads, Thread States, Creating And Interrupting Threads, Thread Priorities, Synchronizing Threads, Inter-Thread Communication, Procedure Consumer Pattern.

Unit IV: [12L]
Collection Framework - Introduction, Generics and Common Use Of Collection Classes, Array List, Vector, Hash Table, Stack, Enumeration, Iterator, String Tokenizer, Random, Scanner, Calendars And Properties.
Files - Streams - Byte Streams, Character Streams, Text Input/Output, Binary Input/Output, Random Access of File Operations, File Management.

Connecting To Database – JDBC / ODBC Type 1 To 4 Drivers, Connection And Handling Databases With JDBC.

Unit V: [12L]
GUI Programming - The AWT Class Hierarchy, Introduction To Swing, Swing Vs, AWT, Hierarchy Of Swing Components, Containers - Jframe, Japplet, Jdialog, Jpanel, Overview Of Swing Components: Jbutton, Jlabel, Jtextfield, Jtextarea, Swing Applications, Layout Management - Types - Border, Grid And Flow
Event Handling - Events, Sources, Classes, Listeners, Event Sources And Listeners, Delegation Event Model, Examples. Handling Mouse Events, Adapter Classes.

Applets - Inheritance Hierarchy For Applets, Differences Between Applets And Applications, Life Cycle, Passing Parameters To Applets, Applet Security Issues.

Text Books:
1. Java Fundamentals - A Comprehensive Introduction, Illustrated Edition By Daleskrien, Herbert Schildt, Mcgraw-Hill Education.

Reference Books:
1. Java for Programmers, 2nd Edition by Paul Deitel and Harvey Deitel, Pearson Education.
2. Thinking In Java, Low Price Edition By Bruce Eckel, Pearson Education

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Define Abstraction in all forms and in a holistic way	PO1, PO12, PSO3
CO2	Illustrate object-oriented modelling techniques like classes and Instances modelling techniques	PO1, PO3, PO5, PO12, PSO3
CO3	Solve programs using standard design patterns	PO1, PO2, PO3, PO4, PO5, PO12, PSO3
CO4	Interpret fundamentals of object-oriented programming in Java, including defining Classes, invoking methods, using class libraries, etc.	PO1, PO3, PO12, PSO3
CO5	Construct programming solutions with exception handling and multi-threading concept	PO1, PO3, PO4, PO5, PO12, PSO3
CO6	Solve GUI program with proper event handling techniques	PO1, PO3, PO4, PO5, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11657	Elective Programming Language II	3	1	3	3	3	-	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE12658	Elective Programming Language II Lab	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	0	0	2	2
Pre-requisite/Exposure	Discrete Mathematics, Calculus, Machine Learning				
Co-requisite					

Course Objectives:

To understand how to design, implement, test, debug, and document programs that use basic data types and computation, simple I/O, conditional and control structures, string handling, functions and object oriented approaches.

Course Outcomes:

On the completion of this course the student will be able to

CO1. **Define** classes, objects, members of a class and the relationships among them needed for a finding the solution to specific problem.
CO2. **Illustrate** object oriented modelling techniques like classes and Instances modelling techniques
CO3. **Solve** programs using standard design patterns.
CO4. **Interpret** fundamentals of object-oriented programming in Java, including defining Classes, invoking methods, using class libraries, etc.
CO5. **Construct** programming solutions with exception handling and multi-threading concept
CO6. **Solve** GUI program with proper event handling techniques.

Catalog Description:

This course investigates object-oriented methods including object-oriented programming methodologies and techniques. Current methodology is emphasized. The use of object-oriented features such as encapsulation, information hiding, inheritance and polymorphism is reinforced by class assignments and programming exercises. The importance of multi-threading and exception handling is introduced in this course.

Course Content:

List of Programs:

Experiment 1:

Assignments based on class, constructor.

Experiment 2:

Assignments based on overloading.

Experiment 3:

Assignments based on inheritance, overriding.

Experiment 4:

Assignments based on wrapper class, arrays.

Experiment 5:

Assignments based on developing interfaces- multiple inheritances, extending interfaces

Experiment 6:

Assignments based on creating and accessing packages

Experiment 7:

Assignments based on multithreaded programming

Experiment 8:

Assignments based on applet programming

Text Books:

1. Java Fundamentals - A Comprehensive Introduction, Illustrated Edition By Daleskrien, Herbert Schildt, Mcgraw-Hill Education.

Reference Books:

1. Java for Programmers, 2nd Edition by Paul Deitel and Harvey Deitel, Pearson Education.
2. Thinking in Java", Low Price Edition By Bruce Eckel, Pearson Education

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** classes, objects, members of a class and the relationships among them needed for a finding the solution to specific problem.	PO1, PO12, PSO3
CO2	**Illustrate** object-oriented modelling techniques like classes and Instances modelling techniques	PO1, PO3, PO5, PO12, PSO3
CO3	**Solve** programs using standard design patterns.	PO1, PO2, PO3, PO4, PO5, PO12, PSO3
CO4	**Interpret** fundamentals of object-oriented programming in Java, including defining Classes, invoking methods, using class libraries, etc.	PO1, PO3, PO12, PSO3
CO5	**Construct** programming solutions with exception handling and multi-threading concept	PO1, PO3, PO4, PO5, PO12, PSO3
CO6	**Solve** GUI program with proper event handling techniques.	PO1, PO3, PO4, PO5, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE12658	Elective Programming Language II Lab	3	1	3	3	3	-	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CHM11153	ELECTIVE CHEMISTRY II	L	T	P	C
Version 1.0		3	1	0	4
Pre-requisites/Exposure	Physics and Chemistry of class 12 or 10+2 level				
Co-requisites	Partial differentiation, model making, graph plotting				

Course Objectives:

1. To introduce important concepts required in the field of the course advanced elective chemistry. This course gives students a thorough understanding regarding fundamental knowledge of various branches of chemistry.
2. To introduce clear understanding of regarding the stabilization of colloidal systems and how solution properties are affected with different dissolutions.
3. To impart the basic notions of chemical equilibrium.
4. To impart detailed descriptions of basic properties of organic molecules and their related reaction mechanism which play major roles in everyday life cycle.
5. To learn the elementary concepts of acid-base chemistry required for daily life chemistry.
6. To understand the major role of inorganic complexes in living organisms which are very essential concepts in the course curriculum of some disciplines.
7. To introduce important tools of different spectroscopic methods required in structure analysis of molecules.

Course Outcomes:

On completion of this course, the students will be able to

CO1	Describe fundamental principles and theories for stabilisation/destabilisation of colloidal systems.
CO2	Explain, using LeChâtelier's Principle, how the equilibrium quantities of reactants and products are shifted by changes in the parameters of the chemical reactions
CO3	Understand the properties of solutions that depends on the number of dissolved particles in solution, but not on the identities of the solutes
CO4	Justify a reasonable mechanism for a chemical reaction
CO5	Study the acid-base concept in aqueous and non-aqueous media and reactions in non-aqueous media.
CO6	Understand the fundamental tasks performed by inorganic elements in living organisms as well as the related methods.
CO7	Identify the structure of unknown/new compounds with the help of different spectroscopic methods like UV-Visible, IR and NMR spectroscopic Technique.

Course Description:

This course gives a detailed understanding of the basics of physical, organic, bioinorganic and spectroscopic knowledge required in other disciplines. This course will include expert instructors who will introduce the importance of chemical equilibrium, property of colloidal states, preliminary concepts of organic chemistry, stereochemistry and some and their various mechanisms, basic bioinorganic chemistry and spectroscopic methods required in analysing

chemical structures. All the lectures will be devoted on discussions of elementary concepts and cutting-edge topics, focusing on practical implementation of knowledge. Instructors will conduct theory classes by taking lecture as well as power point presentations, audio visual virtual lab sessions as per requirement of the course. After finishing this course, students from different disciplines will strongly grasp the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

Physical Chemistry-II

Unit-I: Colloids

Colloids and crystalloids; classification of colloids; Preparation and purification of colloids; Properties of colloids: Brownian motion, peptization, dialysis, Tyndal effect and its applications. Protecting colloids, Gold number, Isoelectric points, Coagulation of colloids by electrolytes, Schulze-Hardy rule. **[5L]**

Unit II: Chemical and Ionic equilibrium

Concept of Gibbs Free Energy; Criteria for thermodynamic equilibrium and spontaneity of a process; Chemical equilibria of homogeneous and heterogeneous systems, Derivation of expression of equilibrium constants; Temperature, pressure and concentration dependence of equilibrium constants (Kp, K. Kx); Le Chatelier's principle of dynamic equilibrium. Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).Concept of salt hydrolysis; Buffer solution and buffer capacity. **[10L]**

Organic Chemistry I

Unit-I: Fundamentals of Organic Chemistry and Stereochemistry:

Functional group-based classification and nomenclature; Sources I origin of different compounds; Concept of hybridization; resonance (including hyperconjugation); inductive effect; steric effect; steric inhibition of resonance. Orbital pictures of bonding (spa, sp2, sp: C-C, C-N & C-O system).

Stereochemistry: Symmetry elements, Molecular chirality, Concept of Stereo Centre, Representation of molecules in Fischer projection, Concept of E/Z and Cis-Trans stereo-isomers. [**5L]**

Unit-II:

Mechanistic classification: ionic, radical and pericyclic; heterolytic and homolytic bond cleavage and bond formation; representation of mechanistic steps using formalism. Reactive intermediates: carbocations (cabenium and carbonium ions), Carbanions, Carbon radicals, Carbenes-structure using orbital picture, Electrophilic/nucleophilic behaviour, Stability, generation and fate (elementary idea); Nucleophilic and electrophilic substitution reaction (only sp centre); Introduction to Elimination reaction and its types. **[3L]**

Unit-III:

Basic Organic Reactions: (Addition, Substitution, Elimination, Rearrangement Reactions) Addition Reactions: Halogenations, Hydration, Hydrogenation, Epoxidation, Hydroxylation, Ozonolysis, electrophilic addition to diene; Hydroboration-oxidation reaction; Radical addition: HBr addition, Birch Reduction. Nucleophilic addition to carbonyl group.

Substitution Reactions: SN 1 , SN2, NGP, Elimination Reactions: El, E2, Elimination vs. Substitution, Rearrangement Reactions: Rearrangement to electron-deficient carbon: Wagner-Meerwein rearrangement, pinacol-pinacolon and related rearrangements, dienone-phenol.

[7L]

Inorganic Chemistry-II:

Unit-I:

Acids-Bases and Redox: Bronsted- Lowry concept of acid-base reaction, solvated proton, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle. Theory of acid-base titration and significance of Acid-base indicators. Common ion effect ;Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions; Nernst equation (without derivation); redox indicators. **[7L]**

Unit-II:

Bioinorganic Chemistry:

Elements of life: essential major, trace and ultra-trace elements; Basic chemical reactions in the biological systems and the role of metal ions (specially Na+, K+, Mg2+, Ca2+, Fe3+, 12+ , Cu2+, R- ,and Zn2+);Biological functions of haemoglobin and myoglobin. **[8L]**

Spectroscopy: **[15L]**

Unit-I:

UV-Vis Spectra: Electronic transition, relative positions of k-max, Woodward's empirical rule; Lambert-Beers Law.

Unit-II:

IR Spectra: Modes of molecular vibrations, application of Hooke's law, characteristic stretching frequencies and factors effecting stretching frequencies.

Unit-III:

NMR Spectra: Preliminary idea of NMR, Nuclear spin, NMR active nuclei, Equivalent and non-equivalent carbons and protons; Chemical shift 6; Shielding deshielding, Upfield and Downfield shifts.

Unit-IV:

Photochemistry: Fluorescence and phosphorescence; Quantum Yield; Jablonsky diagram

References:

Physical Chemistry:

1. D. A. Mcquarrie and J. D. Simon: Physical Chemistry — A Molecular Approach

2. G. W. Castellan: Physical Chemistry

3. P. W. Atkins: Physical Chemistry

Organic Chemistry:

1. D. Nasipuri: Stereochemistry of organic compounds: Principles and Applications

2. P. Sykes: A Guide to Mechanism in Organic Chemistry

3. R. T. Morrison and R. N. Boyd: Organic Chemistry

Inorganic Chemistry:

1. Bioinorganic Chemistry. Asim K. Das.

Spectroscopy:

Organic Spectroscopy. William Kemp.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs)

Mappings between COs and POs		
Course Outcomes (COs)		**Mapped POs**
CO1	Describe fundamental principles and theories for stabilisation/destabilisation of colloidal systems.	PSO1, PO1, PO3
CO2	Explain, using LeChâtelier's Principle, how the equilibrium quantities of reactants and products are shifted by changes in the parameters of the chemical reactions.	PSO1, PO1, PO2, PO3
CO3	Understand the properties of solutions that depends on the number of dissolved particles in solution, but not on the identities of the solutes.	PSO1, PO1, PO2, PO12
CO4	Justify a reasonable mechanism for a chemical reaction.	PSO1, PO1, PO5, PO12
CO5	Study the acid-base concept in aqueous and non-aqueous media and reactions in non-aqueous media.	PSO2, PO1, PO3, PO12
CO6	Understand the fundamental tasks performed by inorganic elements in living organisms as well as the related methods.	PSO1, PO1, PO3, PO5, PO12
CO7	Identify the structure of unknown/new compounds with the help of different spectroscopic methods like UV-Visible, IR and NMR spectroscopic Technique.	PSO1, PO2, PO12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CHM 11153	ELECTIVE CHEMISTRY II	3	3	3	-	2	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CHM12154	ELECTIVE CHEMISTRY LAB II	L	T	P	C
Version 1.0		0	0	3	2
Pre-requisites/Exposure	Physics and Chemistry of class 12 or 10+2 level				
Co-requisites	Partial differentiation, model making, graph plotting				

Course Objectives:

1. To introduce important concepts required in the field of the practical field of elective chemistry. This course gives students a detailed understanding of lab-based chemistry knowledges in their course curriculums.
2. To introduce hands on training of small instruments required for quantitative elemental determination.
3. To impart hand on training on qualitative determination of various acid and base radicals in inorganic complexes.
4. To introduce practical training on qualitative determination of functional groups present in an organic molecule.

Course Outcomes:

On completion of this course, the students will be able to

CO1 Explain various quantitative determination methods using small instruments.

CO2 Illustrate qualitative determination of various acid and basic radicals in an inorganic complex.

CO3 Identify various functional groups in the given organic compounds.

Course Description:

This course gives a detailed understanding of the basics of chemistry lab techniques required in other disciplines. This course will include expert instructors who will introduce a detailed description of lab-based chemistry knowledges in their course curriculums, methods of using small instruments like potentiometer, conductometer for quantitative titration, determination of acid and basic radicals in inorganic complexes and functional groups present in organic molecules. All the lectures will be devoted on discussions of elementary concepts and cutting-edge topics, focusing on practical implementation of knowledge. Instructors will conduct demonstration classes by taking lecture followed by practical hands-on training per requirement of the course. The tutorials and required assignments will acquaint the students with practical problem-solving techniques led by the course coordinator. After finishing this course, students from different disciplines will strongly acquire the hands-on training via experiencing practical lab sessions with the coordinator.

Course Content:

Practical II a: **[15 L]**

1. Determination of E0 of Fe+3/Fe+2 couple in the hydrogen scale by potentiometric titration of ferrous ammonium sulfate solution using KMnO4, or, K2Cr2O7 as standard.

2.Determination of concentration of (i) AgNO3 solution and (ii) solubility product of AgC1 by potentiometric titration of standard KC1 solution against AgNO3 solution.

3. Detection of some acid and basic radicals present in water, soil etc.

Practical IIb: **[15L]**

1. To study the kinetics of inversion of sucrose using polarimeter.
2. Experiment A: Detection of special elements (N, Cl, and S) in organic compounds.
   Experiment B: Solubility and Classification (solvents: H20, dil. HC1, dil. NaOH)
   Experiment C: Detection of functional groups -NO2, -NH2, -COOH, carbonyl (-CHO, >C=0), -OH (phenolic) in solid organic compounds.

References:

1. Das, S.C. Advanced Practical Chemistry, Sixth edition

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Class Assessment	End Term
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs)

Mappings between COs and POs		
Course Outcomes (COs)		**Mapped POs**
CO1	Explain various quantitative determination methods using small instruments.	PSO1, PO3, PO5
CO2	Illustrate qualitative determination of various acid and basic radicals in an inorganic complex.	PSO1, PO1, PO2, PO3
CO3	Identify various functional groups in the given organic compounds.	PSO3, PO1, PO2, PO3, PO5

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CHM 12154	ELECTIVE CHEMISTRY LAB II	3	3	3	-	2	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

EIC11001	Venture Ideation	L	T	P	C
Version 2.0		2	0	0	2
Pre-requisites/Exposure	Basic knowledge of English and computer applications such as Internet Explorer and MS Office				
Co-requisites	--				

Course Objectives:

1. To help the students understand the way to be an entrepreneur
2. To identify the right business opportunity
3. To empower students to perform a technical feasibility study and thereby developing a prototype
4. To help students in identifying their customers using primary and secondary research methods.
5. Expose students to various factors of market and competition with the help of market feasibility study, forecasting techniques, business model canvass and insights about financial statements.
6. To prepare students with finalizing their entrepreneurial Portfolio

Course Outcomes:

On completion of this course, the students will be able to:
CO1. Assess personal capacity in the context of the entrepreneurial process
CO2. Assess characteristics of successful entrepreneurs and entrepreneurial forms and processes
CO3. Apply resources, research and tools for Entrepreneurial ventures
CO4. Analyse and apply opportunity identification techniques, feasibility, terminology, processes and models
CO5. Develop Ideation and planning documents for entrepreneurial venture

Course Description

Over the last decade, the core of our economy has been transitioning from one of industrial might, large monolithic corporations and mass production towards one of networks, flexible enterprises comprising many smaller units and unique value. This new economy is based on innovation originating in creativity and design; it is also disrupting long-standing and established employment patterns and bringing to the fore the importance of entrepreneurship. This core unit will bring together creativity, design and entrepreneurship at the conceptual and more practical level. It aims to explore the nature, determinants and consequences of creativity, design and entrepreneurship as well as the interaction between them.

Course Content

Unit 1. Introduction [08L]

Preview of the Course, Introduction to the Course, Guest Lecture with U.S. Secretary of Commerce Penny Pritzker – Meaning of Innovation, Entrepreneurial opportunities, Factors influencing the feasibility of an innovation, Innovation strategy: technology-push or market-pull, Product-market fit, How to develop a business model, Walkthrough of the business model canvas, Welcome to Innovation for Entrepreneurs: From Idea to Marketplace.

Unit 2. Customer Discovery and Validation [06L]

Customer types, Customer archetypes, Customer segments and business models, Customer segments, value propositions, product features, value mapping, interviewing customer, insights of your customers.

Unit 3: Product Understanding and Marketing. [0**8L]**

Customer value, The DNA of customer-centricity, Crossing the chasm, Qualitative and quantitative marketing research, importance and methods of market segmentation, Focusing on

the target market, Beyond the chasm, Strategic implications of beyond the chasm, E-commerce: The internet as a selling platform.

Unit 4. Prototyping and Testing. [08L]

Planning for prototyping, Rapid prototyping and development, Lean startup MVPs, Choosing a wire framing/UX prototyping tool, Anatomy of an experience map, What you'll learn from user testing, Analytics and insight, Troubleshooting your customer discovery, Levels of a product/service.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped Program Outcomes
CO1	Assess personal capacity in the context of the entrepreneurial process	**PO6, PO11**
CO2	Assess characteristics of successful entrepreneurs and entrepreneurial forms and processes	**PO6, PO11**
CO3	Apply resources, research and tools for Entrepreneurial ventures	**PO6, PO8, PO11**
CO4	Analyze and apply opportunity identification techniques, feasibility terminology, processes and models	**PO6, PO8, PO11**
CO5	Develop Ideation and planning documents for entrepreneurial venture	**PO6, PO8, PO11**

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EIC11001	Venture Ideation	-	-	-	-	-	3	-	3	-	-	3	-	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11075	Sampling Theory	L	T	P	C
Version 1.0	**Contact Hours - 45**	2	1	0	3
Pre-requisites/Exposure	Knowledge of Probability Theory & Theoretical Distributions				
Co-requisites	--				

Course Objectives:
To give students the lessons of solving problems related to sampling theory, which can be constructed from real life problems with some constraints.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Demonstrate** the basic concepts of Sampling Theory and Sampling Distributions of a Statistic.
CO2. **Develop** knowledge on the exact Sampling Distributions - χ^2, t and F.
CO3. **Illustrate** the method of finding Sampling Distributions from Bivariate Normal population.
CO4. **Solve** problems related to Order Statistics and distributions of Sample Median and Sample Range.

Course Description:
This course will give students a preliminary idea on sampling, population, parameter, statistic etc. They will learn several methods to obtain sampling distributions. Various sampling distributions like χ^2 , t and F will be discussed along with their contribution to testing of hypothesis' problems. Additionally, distribution of sample correlation and sample regression coefficients will be derived. Applicability of order statistics through sample median and sample range will be elaborated through practical examples.

Course Content:

Unit I: Basic concepts of Sampling Theory [12L]
Concepts of Population & Parameter, Random Sample & Statistic. Types of Population & Sampling. Sampling Distribution of a Statistic and its numerical applications. Sampling Fluctuations & Standard Error of a Statistic. Techniques of obtaining Sampling Distributions of functions of random variables – CDF technique, Generating Functions technique, Transformation of variables technique with examples.

Unit II: Exact Sampling Distributions [18L]
χ^2 distribution, definition and derivation of its p.d.f. with 'n' degrees of freedom (d.f.), nature of p.d.f. curve for different degrees of freedom, mean, variance, M.G.F., additive property of χ^2 distribution. Derivation of the sampling distribution of sample mean and variance for a Normal population. Student's and Fisher's t-distributions: Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance and limiting form of 't' distribution.
Snedecor's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance. Distribution of 1/F (n1, n2). Relationship between t, F and χ^2 distributions. Applications of t, F and χ2 distribution in testing of significance problems.

Unit III: Sampling Distributions from Bivariate Normal population and Order Statistics [15L]

Distributions of sample means, sample variances and sample correlation coefficient (null case) of a random sample from a Bivariate Normal Population, distribution of the simple regression coefficient (for both stochastic and non-stochastic independent variable cases).

Order Statistics: Introduction, distribution of the r^{th} Order Statistic, smallest and largest Order Statistics. Joint distribution of Order Statistics, distribution of sample median and sample range. Applications.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2003): An Outline of Statistical Theory, Vol I, 4^{th} Edn., The World Press, Kolkata.

T2. Rohatgi V. K. and Saleh A.K. Md. E. (2009): An Introduction to Probability and Statistics, 2^{nd} Edn. (Reprint), John Wiley and Sons.

Reference Books

R1. Mood A.M., Graybill F.A. and Boes D.C. (2007): Introduction to the Theory of Statistics, 3^{rd} Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

R2. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Mathematical Statistics: A Modern Approach. S. Chand & Company

R3. Hogg R.V. & Craig A.T. (1978): Introduction to Mathematical Statistics, Prentice Hall.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** the basic concepts of Sampling Theory and Sampling Distributions of a Statistic.	PO1, PO5, PO12, PSO2
CO2	**Develop** knowledge on the exact Sampling Distributions - χ^2, t and F.	PO1, PO3, PO6, PO12
CO3	**Illustrate** the method of finding Sampling Distributions from Bivariate Normal population.	PO3, PO5, PO12, PSO3
CO4	**Solve** problems related to Order Statistics and distributions of Sample Median and Sample Range.	PO3, PO5, PO6, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11075	Sampling Theory	3	-	3	-	3	3	-	-	-	-	-	3	-	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11076	Statistical Inference	L	T	P	C
Version 1.0	**Contact Hours - 60**	3	1	0	4
Pre-requisites/Exposure	Knowledge of Probability and Probability Distributions				
Co-requisites	Sampling Theory				

Course Objectives:

To give students the lessons of solving problems related to Statistical Inference and its different classifications, which can be constructed from real life problems with some constraints.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Interpret** the concepts of Estimation, Unbiasedness, Sufficiency, Consistency and Efficiency, Complete Statistic, Minimum Variance Unbiased Estimator and Minimum Variance Bound.

CO2. **Construct** the Statistical Hypothesis and error analysis with calculation of Significance Level & Power of test.

CO3. **Develop** the concepts of MP and UMP Tests and applications of Neyman-Pearson Lemma.

CO4. **Make use of** non-parametric techniques in performing Statistical tests.

Course Description:

The course is based on estimators, their properties, and estimation methods. This course will help the students to obtain estimators for population parameters using the various estimation techniques appropriate for specific situations. The students will be able to perform various statistical tests to interpret testing of hypothesis problems. Additionally, non-parametric methods are applied to various real-life problems.

Course Content:

Unit I : Basic concepts of Statistical Inference and Point Estimation [20L]

Introduction to the problem of Statistical Inference, Classifications, Point and Interval Estimation, Confidence Level, Testing of Hypothesis.

Concepts of Estimation, notions of Mean Square Error, Unbiasedness, Best Linear Unbiasedness and Minimum Variance Unbiasedness. Necessary and sufficient condition for Uniformly Minimum Variance Unbiased Estimators (UMVUE). Properties of UMVUE. Consistent Estimators and Asymptotic Efficiency. Sufficiency, Factorization theorem (discrete case only). Fisher's information (for single parameter only). Cramer-Rao Inequality and Minimum Variance Bound (MVB) estimators, Rao-Blackwell and Lehmann-Scheffe theorems and their applications.

Methods of Point Estimation: Method of Moments, Method of Maximum Likelihood Estimation and statements of their properties. Applications.

Unit II: Elements of Hypothesis Testing [15L]

Null and Alternative Hypotheses, Simple & Composite Hypotheses, Critical Region, Type I and Type II Errors, Level of Significance, Size, Power, p-value. Exact tests and confidence intervals: classical and p-value approaches. Tests of significance related to Binomial proportion(s), Poisson mean(s), Univariate Normal mean(s), standard deviation(s) and Bivariate Normal parameters. Combination of probabilities in tests of significance.

Unit III: Theory of Hypothesis Testing **[15L]**

Test function, Randomized and Non-randomized Tests, Most Powerful (MP) Test, Uniformly Most Powerful (UMP) Test, Neyman - Pearson Lemma (statement and proof of sufficiency part only) and its applications to construct MP and UMP tests, Uniformly Most Powerful Unbiased (UMPU) Tests (definition only). Likelihood Ratio Tests, properties of Likelihood Ratio Tests (without proof), Applications.

Unit IV: Non-parametric Tests **[10L]**

Introduction and Concept, Test for randomness based on total number of runs, Empirical distribution function, One Sample Tests: Kolmogrov- Smirnov, Sign, Signed rank. Wilcoxon-Mann-Whitney test. Kruskal-Wallis test.

Text Books

T1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons

T2. Casella G. and Berger R.L. (2002): Statistical Inference, 2nd Edn., Thomson Learning.

Reference Books

R1. Goon A.M., Gupta M.K. & Dasgupta B. (2005): An Outline of Statistical Theory, Vol. I & II, The World Press, Kolkata

R2. Miller I. and Miller M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.

R3. Gupta S. C., & Kapoor V. K. (1975). Fundamentals of Mathematical Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Interpret** the concepts of Estimation, Unbiasedness, Sufficiency, Consistency and Efficiency, Complete Statistic, Minimum Variance Unbiased Estimator and Minimum Variance Bound.	PO1, PO12
CO2	**Construct** the Statistical Hypothesis and error analysis with calculation of Significance Level & Power of test.	PO1, PO3, PO4, PO12, PSO2, PSO3
CO3	**Develop** the concepts of MP and UMP Tests and applications of Neyman-Pearson Lemma.	PO3, PO4, PO6, PO12, PSO2, PSO3
CO4	**Make use of** non-parametric techniques in performing Statistical tests.	PO3, PO6, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11076	Statistical Inference	3	-	3	3	-	3	-	-	-	-	-	3	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12077	Statistical Inference Practical	L	T	P	C
Version 1.1	Contact Hours - 45	0	0	3	2
Pre-requisites/Exposure	Probability Distributions and Statistical Inference				
Co-requisites	Knowledge of R Programming				

Course Objectives:
To provide students knowledge of practical implementation of different Statistical Inference procedures.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Solve** problems related to Unbiased Estimators and Maximum Likelihood Estimators.
CO2. **Solve** problems related to Testing of Hypothesis and MP critical region (NP lemma).
CO3. **Illustrate** Uniformly Most Powerful and Unbiased critical region and Power Curves.
CO4. **Experiment with** Non-parametric techniques in performing Statistical tests.

Course Description:
This course will help students to solve problems regarding estimation, testing of hypothesis and non-parametric methods with the help of programming language R. They will be taught fundamentals of the concerned language and then proceed to write codes in R. They will be able to experiment and write codes in such a way that they can find the solutions, visualize the analysis etc., without using mathematical derivations.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or R Programming)

Sl. No.	Name of the Experiments
1	Unbiased Estimators (including Unbiased but absurd Estimators).
2	Maximum Likelihood Estimation.
3	Estimation by the Method of Moments.
4	Test of significance for single proportion and difference of two proportions.
5	Test of significance for single Poisson mean and difference of two Poisson means.
6	Test of significance and confidence intervals for single mean and difference of two means.
7	Test of significance and confidence intervals for single variance and ratio of two variances.
8	Test of parameters under Bivariate Normal distribution.
9	Type I and Type II Errors.
10	Most Powerful Critical Region (NP Lemma).
11	Uniformly Most Powerful and Unbiased Critical Region.
12	Power Curves.
13	Test for randomness based on total number of runs.
14	Kolmogorov-Smirnov test for one sample.
15	Sign test.
16	Signed Rank test.
17	Wilcoxon-Mann-Whitney test.
18	Kruskal-Wallis test.

Text Books

T1. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons

T2. Casella G. and Berger R.L. (2002): Statistical Inference, 2nd Edn., Thomson Learning.

Reference Books

R1. Goon A.M., Gupta M.K. & Dasgupta B. (2005): An Outline of Statistical Theory, Vol. I & II, The World Press, Kolkata

R2. Miller I. and Miller M. (2002): John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.

R3. Gupta S. C., & Kapoor V. K. (1975). Fundamentals of Mathematical Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		**Mapped POs and PSOs**
CO1	**Solve** problems related to Unbiased Estimators and Maximum Likelihood Estimators	PO3, PO4, PO6, PO12
CO2	**Solve** problems related to Testing of Hypothesis and MP critical region (NP lemma)	PO3, PO4, PO6, PO12, PSO2, PSO3
CO3	**Illustrate** Uniformly Most Powerful and Unbiased critical region and Power Curves	PO3, PO4, PO6, PO12, PSO2, PSO3
CO4	**Experiment with** Non-parametric techniques in performing Statistical tests	PO3, PO6, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12077	Statistical Inference Practical	-	-	3	3	-	3	-	-	-	-	-	3	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11078	Index Numbers and Time Series Analysis	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Degree Level Statistics and Basic Mathematics Knowledge				
Co-requisites	--				

Course Objectives:
To provide students the fundamental knowledge of different statistical methods of Index Numbers and Time Series Analysis along with their applications.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Build** the concepts of various Index Numbers and their uses
CO2. **Develop** the concepts of different components and models of a Time Series data
CO3. **Estimate** the Trend and Seasonal components using different methods
CO4. **Utilize** Moving Average and Auto Regressive Process in Forecasting

Course Description:
This course will help students to acquire preliminary idea about Index numbers and their utility. They will be accustomed to several components of time series data along with some methods to estimate the trend and seasonality. They will be able to implement different methods to forecast time series data.

Course Content:

Unit I: Index Numbers [15L]
Weighted means, Price and Quantity Index Numbers, Value Index, Construction, Uses, Limitations, Laspeyres' and Paasche's Index Numbers. Tests of Index Numbers and Fisher's ideal Index Number, Chain Index Number.
Consumer Price Index Number, Wholesale Price Index Number and Index Number of Industrial Production – methods of construction and uses.

Unit II: Introduction to Time Series and Estimation of Trend [13L]
Introduction to Time Series data, application of Time Series from various fields. Modelling Time Series as deterministic function plus IID errors. Components of a Time Series (Trend, Seasonal and Cyclical patterns, Random error). Decomposition of Time Series. Additive and Multiplicative models. Estimation of Trend: Free hand curve method, method of Moving Averages, fitting various Mathematical Curves and Growth Curves. Effect of elimination of Trend on other components of the Time Series.

Unit III: Estimation of Seasonal Component and Introduction to Stochastic Modelling [12L]
Estimation of Seasonal component by Method of Simple Averages, Ratio-to-Moving Average, Ratio-to-Trend. Introduction to Stochastic modelling: Concept of Stationarity. Illustration of how a Stationary Time Series may show temporal patterns. Stationarity in mean. Auto-covariance (ACVF) and Auto-correlation functions (ACF) and their properties.

Unit IV: Box-Jenkins modelling and Forecasting [20L]

Moving-average (MA) process and Autoregressive (AR) process of orders one and two. ACF and its graphical use in guessing the order of MA processes. Estimation of the parameters of AR (1) and AR (2) using Least Square and Yule-Walker equations. Introduction to ARMA and ARIMA models. Forecasting: Exponential Smoothing methods.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.

T2. Brockwell and Davis (2010): Introduction to Time Series and Forecasting (Springer Texts in Statistics), 2nd Edition.

T3. Mukhopadhyay P. (1999): Applied Statistics, Books & Allied Pvt. Ltd.

Reference Books

R1. Chatfield C. (1980): The Analysis of Time Series – An Introduction, Chapman & Hall.

R2. Kendall M.G. (1976): Time Series, Charles Griffin.

R3. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan

R4. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	**Mid-term Examination**	**Continuous Assessment**	**End Term Examination**
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		**Mapped POs and PSOs**
CO1	**Build** the concepts of various Index Numbers and their uses.	PO1, PO12, PSO2
CO2	**Develop** the concepts of different components and models of a Time Series data	PO3, PO6, PO12, PSO2
CO3	**Estimate** the Trend and Seasonal components using different methods	PO3, PO6, PO7, PO12, PSO3
CO4	**Utilize** Moving Average and Auto Regressive Process in Forecasting	PO3, PO6, PO7, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11078	Index Numbers and Time Series Analysis	2	-	3	-	-	3	3	-	-	-	-	3	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12079	Index Numbers and Time Series Analysis Practical	L	T	P	C
Version 1.0	**Contact Hours - 45**	0	0	3	2
Pre-requisites/Exposure	Theory of Index Numbers and Time Series Analysis				
Co-requisites	Knowledge of MS Excel				

Course Objectives:

To provide students the hands-on experience of different statistical methods of Index Numbers and Time Series Analysis along with their applications.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Build** the concepts for finding out various Index Numbers and their corresponding tests
CO2. **Interpret** Time Series data through graphical representation and Trend Analysis
CO3. **Estimate** the Seasonal components using Ratio-to-Moving Average and Ratio-to-Trend methods
CO4. **Utilize** Moving Average and Auto Regressive Process in Forecasting

Course Description:

This course will help students to acquire preliminary idea about Index numbers and their utility. They will be accustomed to several components of time series data through visualization, along with some methods to estimate the trend and seasonality. They will be able to implement different methods to forecast time series data. All this will be done with the help of computers. They will be taught regarding this initially. After that, they will be able to find solutions using Microsoft Excel.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or MS Excel)

Sl. No.	Name of the Experiments
1	Calculation of Price and Quantity Index Numbers.
2	Applications on Chain Index Numbers.
3	Construction of Consumer and Wholesale Price Index Numbers.
4	Plotting a real-life Time Series and detecting various features (Trend, periodic behaviours etc.)
5	Fitting and plotting of mathematical curves: Linear, Parabolic, Exponential and Modified Exponential
6	Fitting of Trend by Moving Average Method.
7	Measurement of Seasonal indices Ratio-to-Moving Average method.
8	Measurement of Seasonal indices Ratio-to-Trend method.
9	Plotting ACF of a given Time Series.
10	Using Yule-Walker equations and Least squares to fit AR(1) and AR(2) models to real life data.
11	Forecasting by Exponential Smoothing.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.

T2. Brockwell and Davis (2010): Introduction to Time Series and Forecasting (Springer Texts in Statistics), 2nd Edition.
T3. Mukhopadhyay P. (1999): Applied Statistics, Books & Allied Pvt. Ltd.

Reference Books

R1. Chatfield C. (1980): The Analysis of Time Series – An Introduction, Chapman & Hall.
R2. Kendall M.G. (1976): Time Series, Charles Griffin.
R3. Allen R.G.D. (1975): Index Numbers in Theory and Practice, Macmillan
R4. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Build** the concepts for finding out various Index Numbers and their corresponding tests	PO1, PO12, PSO2
CO2	**Interpret** Time Series data through graphical representation and Trend Analysis	PO3, PO6, PO12, PSO2
CO3	**Estimate** the Seasonal components using Ratio-to-Moving Average and Ratio-to-Trend methods	PO3, PO6, PO7, PO12, PSO3
CO4	**Utilize** Moving Average and Auto Regressive Process in Forecasting	PO3, PO6, PO7, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12079	Index Numbers and Time Series Analysis Practical	2	-	3	-	-	3	3	-	-	-	-	3	-	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS13080	R PROGRAMMING	L	T	P	C
Version 1.0	Contact Hours - 60	1	0	3	3
Pre-requisites/Exposure	12^{th} level Mathematics				
Co-requisites	Basic knowledge of matrix; Basic knowledge of statistics				

Course Objectives:

- To learn fundamentals of R language and coding
- To develop skill for high quality data visualization
- To apply R for solving statistical and real-world problems

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Make use of** R syntaxes to write programs
CO2. **Develop** high quality visualizations of given data set
CO3. **Build** user-defined functions
CO4. **Utilize** R programming to solve different mathematical and statistical problems

Course Description:

This course will introduce students to the fundamentals of R language, data visualization and its application to solve statistical problems. The course will provide information on R software, user interface and scripting; basic operations and in-built functions; defining and manipulating arrays; writing user defined functions; control statements – conditionals (if-else) and loops; importing and exporting data; data visualizations and applications. The class activities include lectures, hands-on practices, tutorials, assignments, quizzes, and interactions. Moreover, the students will actively participate in discussion, problem solving in class. The course will help the students to develop the fundamental knowledge of R language and writing programs, and in addition, to enhance the problem solving, interaction and presentation skills.

Course Content:

Unit I **[08L]**

History of R programming; Usefulness of R; Software (R and RStudio) installation; R software interface – command window, workplace, command history, script editor; use of R as calculator; writing code on command window and on script editor.

Unit II **[24L]**

Different types of objects – numeric, logical, string, factor, vector, matrix, list, data frame; creation, deletion, modification of different object types; operations on objects.

Simple Graphs with R: Line graphs, scattered plots, Bar charts, Histograms, Box plots, Pie charts, Create subplots using par command, Export figures into different file formats.

Unit III **[16L]**

List of operators in R and their uses; conditional statements – if/else conditions; loops – for, while and repeat; use of break and next

Different in-built functions and their uses; writing user-defined functions.

Unit IV **[12L]**

Reading and writing data, importing data from different file formats, working with large data, subsampling, visualize data using R graphics

Text Books

T1. Gardener M., Beginning R: The Statistical Programming Language, Wiley Publication, 2012.

T2. Braun, W. John, and Duncan J. Murdoch., A first course in statistical programming with R. Cambridge University Press, 2021

Reference Books

R1. Emmanuel Paradis, R for Beginners, Online source: https://cran.r-project.org/doc/contrib/Paradis-rdebuts_en.pdf

R2. R Programming, Tutorial point, Online source: https://www.tutorialspoint.com/r/r_tutorial.pdf

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Make use of** R syntaxes to write programs	PO1, PO6, PO5, PO12, PSO1, PSO3
CO2	**Develop** high quality visualizations of given data set	PO1, PO6, PO5, PO12, PSO1, PSO3
CO3	**Build** user-defined functions	PO1, PO6, PO5, PO12, PSO1, PSO3
CO4	**Utilize** R programming to solve different mathematical and statistical problems	PO1, PO6, PO5, PO12, PSO1, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS13080	R PROGRAMMING	3	-	-	-	3	3	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

ECO11001	Microeconomics	L	T	P	C
Version 1.0	**Contact Hours – 90**	5	1	0	6
Pre-requisites/Exposure	-				
Co-requisites	--				

Course Objectives:

1. Introduce students to the terminology and analytic principles used in microeconomics
2. Introduce students to the application of these conceptual tools to several policy issues
3. Explore the decisions of buyers and sellers and their interaction in market transactions.
4. Explore different government interventions such as taxes on subsidies on equilibrium outcomes

Course Outcomes:

CO1. Understand the terminology and analytic principles used in microeconomics in individual decision-making framework
CO2. Understand the application of these conceptual tools to several policy issues
CO3. Analyze the decisions of buyers and sellers and their interaction in market transactions thereby shaping the equilibrium market outcomes.
CO4. Explore different government interventions such as taxes on subsidies on equilibrium outcomes

Course Description:

This paper introduces students to the terminology and analytic principles used in microeconomics, which is broadly defined as the study of markets, and to the application of these conceptual tools to several policy issues. The decisions of buyers and sellers and their interaction in market transactions will be analyzed. This also explores how different market structures can shape economic results, and how markets can sometimes (but not always) help society achieve desirable outcomes.

Course Content:

Unit I: **Demand and Supply** **[15 L]**

Determinants of Demand; Law of Demand; Demand Function, Demand Schedule and Demand Curve; Determinants of Supply; Law of Supply; Supply Function, Supply Schedule and Supply Curve; Shift and movement along the Demand & Supply Curve; Elasticity of Demand – Price, Income, Cross; Elasticity of Supply; Substitutes & Complementary Goods, Normal & Inferior Goods. Equilibrium Determination, Impact of changes in Demand and Supply, Change in Equilibrium, Stability of Equilibrium; Consumer Surplus, Producer Surplus, Deadweight Loss, Change in surplus, Incidence of Tax, Impact of Subsidy.

Unit II: **Theory of Consumption** **[15 L]**

Budget Constraint: Composite goods, Budget Set, Properties of budget set, Budget Line, change in budget line due to change in income and prices, Application: Taxes, Subsidies, Rationing Preferences: Consumer Preferences, basic assumptions about preferences; Indifference Curves, Indifference Map, Marginal Rate of Substitution; Shape of Indifference

curves: Perfect substitutes, perfect complements, Bads, Neutrals, Satiation, Discrete Goods Utility: Cardinal Utility, Utility function, Total utility, Marginal Utility, Ordinal Utility, Preference, MRS Choice: Optimal Choice, Consumer's Equilibrium, Change in Equilibrium due to change in income, and prices, Income Consumption Curve, Engel Curve, Price Consumption Curve, Individual Demand, From individual to market demand; Price Effect: Hicks, Slutsky approach, Income Effect, Substitution Effect, Compensated Demand.

Unit III: Theory of Production **[17 L]**

Technological relationship between output and inputs, Production decision of a firm; Production function, short run versus long run production; Production with single variable input: TP, AP, MP, Law of diminishing marginal return; Production with two variable inputs: Isoquant, Economic region of production, Input flexibility, Input substitution; MRTS, Elasticity of substitution; Expansion Path, Returns to scale; Effects of changes in input prices on output. Special Cases: Homogeneous Production Function, Cobb-Douglas Production.

Unit IV: Costs of Production **[08 L]**

Different types of costs; opportunity cost, sunk cost; fixed cost, variable cost; Costs in the SR production, TC, AC, MC, Cost curves; Costs in the LR production, LR cost curves, relation between SR and LR cost curves; Shift in cost curves. Input choices, Iso-cost line, Change in technology and change in input prices; optimal choice of inputs, Economies of Scope, Economics of Scale, Learning Curve.

Unit V: Market: Perfect Competition **[11 L]**

Profit Maximization by a firm, Competition in a market, Different forms of Competition; Perfectly competitive market and its characteristics, Choosing output in Short Run, SR supply curve, Choosing output in the Long Run, LR Industry supply curve: Increasing cost industry, Decreasing cost industry, and Constant cost industry; Efficiency of a competitive market: Effect of Tax, Minimum Prices, Price Support, Production Quota, Impact of tax and subsidy.

Unit VI: Market: **Imperfect Competition** **[09 L]**

Market Power, Sources, Monopoly, Monopsony, Bilateral Monopoly, Natural Monopoly; Monopolist's Output Decision, and pricing. Monopolistic Competition: Characteristics, Equilibrium in Short and Long run, Economic Efficiency; Branding Oligopoly: market structure, collusion, competition, equilibrium.

Text Books

T1. Intermediate Microeconomics: A Modern Approach. H.R. Varian. East West Press; 8th edition, 2010

T2. Modern Microeconomics. A. Koutsoyiannis. Palgrave Macmillan; 2nd edition, 2008

Reference Books

R1. Microeconomics: Theory and Applications. G.S. Maddala, and E. Miller. McGraw Hill Education (India) Private Limited; 3rd edition, 2004

R2. Microeconomics. R. S. Pindyck, D.L. Rubinfeld, and P.L. Mehta. Pearson, India, 7th edition, 2013

R3. Principles of Microeconomics. D. Salvatore. Oxford University Press (5th or later edition).

R4. Microeconomic Theory. Ferguson, and Gould. All India Traveler Book Sellers (6th edition)

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO-1	**Understand** the terminology and analytic principles used in microeconomics in individual decision making framework	PO1, PO2, PO7, PO9, PO10
CO-2	**Understand** the application of these conceptual tools to several policy issues	PO1, PO2, PO3, PO7, PO9,PO12
CO-3	**Analyse** the decisions of buyers and sellers and their interaction in market transactions thereby shaping the equilibrium market outcomes.	PO2, PO3, PO4, PO7, PO9, PO10, PO12
CO-4	**Explore** different government interventions such as taxes on subsidies on equilibrium outcomes	PO4, PO7, PO10, PO12

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ECO 11001	MICROECONOMICS	2	2	1	1	-	-	3	-	3	3	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

PHY11015	Elective Physics I	L	T	P	C
Version 1.2	Contact Hours - 60	4	0	0	4
Pre-requisites/Exposure	12^{th} level Physics				
Co-requisites	Basic concept of Differential and Integral Calculus				

Course Objectives:

1. To develop the capability of the students for understanding fundamental aspects of physics.
2. To give students theoretical background, the key prerequisite for performing laboratory experiments.
3. To build up idea on basic Newtonian mechanics, general properties of matters, electromagnetic theory and optics. These ideas can upgrade student's understanding in proper channel, so that they can flourish their career path.
4. To explore every day phenomena of the macroscopic world from a scientific point of view.

Course Outcomes:

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

CO1. Develop knowledge of vector differentiation, integration, essential theorems and apply it in further study of physics.

CO2. Relate and illustrate the fundamental principles of dynamics of a single particle and system of particles and apply it in real life problems.

CO3. Define and develop the concepts of work and energy, Conservative and non-conservative forces and Central forces.

CO4. Define and analyse the fundamentals of rotational dynamics of a rigid body, and estimate the Moment of Inertia of different objects, explain Coriolis and Centrifugal forces

CO5. Define and explain the basic concepts of Elasticity, viscosity, surface tension and apply it in different relevant areas

CO6. Develop the basic concepts of electromagnetic theory and apply it in practical situation

CO7. Define, explain and estimate different phenomenon of wave and optics

Course Description:

In Elective Physics I course different aspects of Mathematical Physics is enlisted to explain phenomena in the natural world. This information is then can be used for practical endeavours through a controlled Laboratory environment. In this course the focus will be on improving the logical learning moved into a physical environment. Newtonian mechanics, general properties of matter, electromagnetic theory, these basic field will be covered. We will combine traditional lectures with other active teaching methodologies like digital platform, group discussions, cooperative group solving problems, Course will be concluded with basic understanding of Optics which will make a background to perform optical experiments.

Course Content

Unit I: Vector Analysis [08L]

Axial and polar vectors, dot product and cross product, scalar triple product and vector triple product. Scalar and vector fields --- gradient, divergence and curl, statement of divergence theorem, statement of Stokes' theorem.

Unit II: Newtonian Mechanics **[10L]**

(a) Newton's laws of motion, principle of conservation of linear momentum, time and path integral of force, conservative force field, concept of potential, conservation of total energy, equation of motion of a system with variable mass.

(b) Rotational motion, angular velocity, angular acceleration, angular momentum, torque, fundamental equation of rotational motion, principle of conservation of angular momentum, radial and cross-radial acceleration.

(c) Central force and Gravitation**:** Central force and its properties, Differential equation of orbits under central force field, Gravitational potential and intensity due to thin uniform spherical shell and solid sphere of uniform density, escape velocity.

Unit III: Elasticity **[06L]**

Elastic moduli and their interrelations, bending of a beam, cantilever, simply supported beam with concentrated load at the center.

Unit IV: Viscosity and Fluid Motion **[06L]**

Streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynolds number, Bernoulli's theorem, Stokes' law (statement only).

Unit V: Surface Tension **[06L]**

Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble and spherical drop.

Unit VI: **E M Theory** **[12L]**

Gauss's Law in Electrostatics (in vacuum and in presence of dielectric), Laplace's Equation and Poisson's Equation, Lorentz Force, Motion of Charged Particles in crossed Electric & Magnetic fields, Velocity Selector & Magnetic focussing, Biot-Savart Law and Ampere's Law and their applications, Vector and Scalar potential, Electromagnetic induction, Faraday's Law, Maxwell's equations (differential and integral forms), Poynting vector, Poynting Theorem (Statement only), propagation of plane electromagnetic waves in vacuum, dielectric and conducting media.

Unit VII: Wave and Optics **[12L]**

Differential equation and its solution, analytical treatment, Lissajous figures, natural, damped and forced vibration, resonance, sharpness of resonance. Light as an electromagnetic wave, full electromagnetic spectrum, properties of electromagnetic waves, Huygens' principle, Interference of light, Young's experiment, intensity distribution, conditions of interference, Diffraction of light, Fresnel and Fraunhofer class, Fresnel's half-period zones, zone plate. Fraunhofer diffraction due to a single slit and plane transmission grating (elementary theory). Polarization of light Different states of polarization, Brewster's law.

Text Books

T1. Vector Analysis by Murray R Spiegel
T2. Theoretical mechanics by Spiegel
T3. A Treatise on General Properties of Matter, Sengupta Chatterjee
T4. Electromagnetic Fields (Theory and Problems), TVS Arun Murthy
T5. Principles of Optics, B.K. Mathur, 1995, Gopal Printing

Reference Books

R1. An Introduction To Mechanics, by Robert J. Kolenkow and Daniel Kleppner
R2. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Develop knowledge of vector differentiation, integration, essential theorems and apply it in further study of physics.	PO1, PO6, PO12, PSO1
CO2	Relate and illustrate the fundamental principles of dynamics of a single particle and system of particles and apply it in real life problems.	PO1, PO5, PO7, PSO1, PSO3
CO3	Define and develop the concepts of work and energy, Conservative and non-conservative forces and Central forces.	PO1, PO3, PO6, PO7, PO8, PO11, PSO3
CO4	Define and analyse the fundamentals of rotational dynamics of a rigid body, and estimate the Moment of Inertia of different objects, explain Coriolis and Centrifugal forces	PO1, PO2, PO3, PO11, PSO3
CO5	Define and explain the basic concepts of Elasticity, viscosity, surface tension and apply it in different relevant areas	PO1, PO3, PO7, PO9, PO10, PSO3
CO6	Develop the basic concepts of electromagnetic theory and apply it in practical situation	PO1, PO7, PO9, PO10, PSO3
CO7	Define, explain and estimate different phenomenon of wave and optics	PO1, PO3, PO7, PO9, PO10, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PHY11015	ELECTIVE PHYSICS I	3	-	2	-	-	2	2	2	3	3	1	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

PHY12016	Elective Physics I Lab	L	T	P	C
Version 1.0	Contact Hours – 45 Hours	0	0	3	2
Pre-requisites/Exposure	Basic knowledge on physics experiment (12th level Physics)				
Co-requisites	--				

Course Objectives

1. To develop the capability of the students for practical understanding of fundamental aspects of physics.
2. To give students experimental/laboratory-based background, the key prerequisite for performing research near future.
3. To build up real-time idea on basic Newtonian mechanics, general properties of matters, electromagnetic theory and optics. These ideas can upgrade student's understanding in proper channel, so that they can flourish their career path.

Course Outcomes:

CO 1 Estimate, demonstrate realistic understanding of measurement of general properties of matter and experiment of light

CO 2 Experiment, relate with measurement of Young's modulus by Flexure method

CO 3 Estimate, demonstrate the fundamental idea of experiment with some basic measurement instruments, such as slide callipers, screw gauge etc.

CO 4 Experiment, relate with measurement Rigidity modulus by Dynamic method

CO5 Experiment, relate with measurement of coefficient of viscosity by Poiseuille's capillary flow method, develop idea on conduct experiment with capillary tube

C06 Develop the practical understanding on measurement of surface tension by Jurin's law

CO7 Develop skill enhancement on experiment of light and estimate the Brewster's angle and refractive index of glass Hands-on knowledge on spectrometer (Schuster's focussing), estimate the idea of polarized and un-polarized light by using polaroid

CO8 Develop the visualization of interference pattern of monochromatic light by Newton's ring method and concept of wavelength measurement

Course Description:

In Elective Physics I Lab course different aspects of Physics lab is enlisted to explain phenomena in the natural world. This information is then can be used for practical endeavours through a controlled Laboratory environment. In this course the focus will be on improving the logical learning moved into a physical environment. Newtonian mechanics, general properties of matter, optics, these basic field-based laboratories will be covered. We will combine traditional lab classes with other active teaching methodologies like digital platform, group discussions, cooperative group solving problems, weekly viva.

Course Content:

Experiment 1: **[3L]**

Determination of Rigidity modulus by Dynamic method.

Experiment 2: **[6L]**

Determination of Young's Modulus by Flexure method.

Experiment 3: **[6L]**

Determination of coefficient of viscosity by Poiseuille's capillary flow method.

Experiment 4: **[6L]**

Determination of Surface Tension of a given liquid by Jurin's Law.

Experiment 5: **[6L]**
To determine the value of 'g' using Compound Pendulum.
Experiment 6: **[6L]**
To determine the wavelength of a monochromatic light by Newton's ring method.
Experiment 7: **[3L]**
Dispersive power of the material of the prism using spectrometer and Na light source.
Experiment 8: **[6L]**
Determination Brewster's Angle and Refractive Index of Glass by using spectrometer and Polaroid.
Experiment 9: **[3L]**
Determination of wavelength of a light by LASER diffraction method**.**

Text Books:
T1. Advanced Practical Physics, Volume-I, B. Ghosh & K. G. Mazumdar

Reference Books:
R1: An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam
Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs , POs and PSOs		
	Course Outcomes (COs)	**Mapped POs and PSOs**
CO 1	Estimate, demonstrate realistic understanding of measurement of general properties of matter and experiment of light	**PO1, PO3, PO6, PO12, PSO3**
CO 2	Experiment, relate with measurement of Young's modulus by Flexure method	**PO1, PO, PO7, PO8, PO9, PO10**
CO 3	Estimate, demonstrate the fundamental idea of experiment with some basic measurement instruments, such as slide callipers, screw gauge etc.	**PO6, PO7, PO8, PO9, PSO3**
CO 4	Experiment, relate with measurement Rigidity modulus by Dynamic method	**PO 1, PO 3, PO 9, PO10, PO 12, PSO3**
CO5	Experiment, relate with measurement of coefficient of viscosity by Poiseuille's capillary flow method, develop idea on conduct experiment with capillary tube	**PO1, PO9, PO10, PO12, PSO3**
C06	Develop the practical understanding on measurement of surface tension by Jurin's law	**PO1, PO3, PO6, PO9, PO10, PSO3**
CO7	Develop skill enhancement on experiment of light and estimate the Brewster's angle and refractive index of glass Hands-on knowledge on spectrometer (Schuster's focussing), estimate the idea of polarized and un-polarized light by using polaroid	**PO1, PO9, PO10, PO7, PO8**

CO8	Develop the visualization of interference pattern of monochromatic light by Newton's ring method and concept of wavelength measurement	**PO1, PO8, PO10, PSO3**

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PHY12016	Elective Physics I Lab	3	-	2	-	-	2	2	2	3	3	1	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

IDP14001	Inter-Disciplinary Project	L	T	P	C
Version 1.0		-	-	5	3
Pre-requisites/Exposure	Knowledge of Basic English				
Co-requisites	Knowledge of Basic Computer Skills				

Course Objectives

This course will develop a student's knowledge of and appreciation for the

- interdisciplinary nature of knowledge and learning
- importance and value of integrating knowledge and perspectives from multiple disciplines as a means to evaluating and understanding complex topics, problems, issues, phenomena, and events
- competencies learned during the educational process and to apply these competencies in a real-world application

CourseOutcomes

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

CO1. recognize the unique advantages of integrative research and learning
CO2. understand the fundamentals of research methods and practices of various academic disciplines
CO3. demonstrate an understanding of current issues and concerns
CO4. realize the importance of ethics in research process
CO5. understand the inter-disciplinary systems of research documentation

Typical Progress Roadmap

- After discussion with the Project Advisor(s), each student shallprepare an initial outline of their assigned project indicating the major sections of discussion, list the principal research sources for each section, and explain the overall objective of the project, including a justification of the interdisciplinary nature of the work.
- Each student shall meet with the Project Advisor(s)regularly as per the weekly Time-Table. Other meetings may be scheduled at the discretion of the Project Advisor(s) at mutually agreed upon timings.
- Typically, the progress will include a combination of industrial and academic mentoring , self study sessions, case studies, trend studies, presentation by students, interactive sessions, industrial visits etc.
- Regular submission of progress reports shall be required of each student-group as notified through the Project Advisor(s) from time to time.

Mode of Evaluation

Students will be evaluated by team participation and a team presentation at the end of the project. Interactive & continuous, task/assignment- based evaluation methodology will be applied for the course.

Modes of Examination: Assessment Scheme:

Components	Interactive & continuous	Team presentation
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs):

Course Outcomes (COs)		**Mapped Pos and PSOs**
CO1	**Identify** the unique advantages of integrative research and learning.	**PO1, PO8, PO9**
CO2	**U**nderstand the fundamentals of research methods and practices of various academic disciplines.	**PO1, PO8, PO9**
CO3	**D**emonstrate an understanding of current issues and concerns.	**PO1, PO3, PO8, PO9**
CO4	Recognize the importance of ethics in research process	**PO1, PO8, PO9**
CO5	Comprehend the inter-disciplinary systems of research documentation**.**	**PO1, PO3, PO8, PO9**

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
IDP14001	Inter-Disciplinary Project	3	-	2	-	-	-	-	3	3	-	-	-	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SOC14100	Community Service	L	T	P	C
Version 1.0		-	-	-	1
Pre-requisites/Exposure	Knowledge of Basic English				
Co-requisites	Knowledge of Basic Computer Skills				

Course Objectives:

1. To familiarize the students on the concept 'giving back to the society'.
2. To acquaint the students on the issues faced by marginalized communities.
3. To provide an experiential platform to the students on any one or two issues as an internship.

Course Outcomes:

On completion of this course, the students will be able to
CO1: Understand the concept of social responsibility through an internship.
CO2: Apply hands on experience in 'giving back to the society' through the concept of social responsibility through an internship.

Course Description:

Along with Intelligent Quotient, it is important for students to enhance their Emotional Quotient as well. The Social Internship offers opportunity to the student to be empathetic towards social issues facing our society. To help and support the affected community / cause through a field internship is the essence of the course in 'giving back to the society'.

Course Content

Unit I:

Introduction to the course. A brief on social issues facing the society with both global and Indian examples.

Unit II:

Minimum 24 hours of field work on a social issue and helping the marginalized / affected community / cause with photographs and testimonies.

Unit III:

Submission of individual reflection on the social service rendered.

The benefits that accrue to the students are

A.) Subjective

1. Psychosomatic benefits: Volunteering increases overall life satisfaction and also helps to relive stress and acts as an anti-depressant.
2. Intellectual benefits: Enhances knowledge through new experiences, and develops communication skills.
3. Career benefits: Enhances career prospects by acquisition of work-related skills, builds good references for employers and provides a forum to network with future potential employers. It also the experience allows gained helps students to take up leadership positions. Letters of recommendation can also be easily sought. Research shows that students who indulge in volunteer word perform better in studies as it invigorates their passion for learning
4. Personal benefits: Real world skills like leadership, problem-solving, collaboration with others, time management and communication skills, learn patience and empathy.

5. Connect learning to real world and enables deeper and lifelong learning.

B.) **Community**

1. Collective benefits: Strong interpersonal bonds are created, and leads to increased civic and social awareness and responsibility.

Further Reading:

1. Tadevosyan, Gohar & Schoenhuth, Michael. Participatory Research Approach: Principles, Challenges and Perspectives. http://ysu.am/files/01G_Tadevosyan_M_Schoenhuth.pdf
2. Bergold, Jarg& Thomas Stefan. Participatory Research Methods: A Methodological Approach in Motion http://www.qualitative-research.net/index.php/fqs/article/view/1801/3334

Plan of Work

1. Reading on social issues facing the society with both global and Indian examples.
2. Selecting an issue where the student wishes to contribute and wants to make a difference.
3. Areas - The internship may be broadly completed by getting in touch with NGO in your city / town / Police / Municipal Corporation / Local Gram Panchayat / Hospital / State Health Department / Women & Child Development Centre / CSR departments of Corporates /school / Old Age Home / Orphanage / Literacy Drive / Aanganwadi Centres / etc.
4. **Online Discussion –** Through discussion, students elaborate their preferred area of work with reference to the Global Scenario and India. Reason for choosing that area also needs and resources of the people in their area of Social Internship and also submit the testimonials, which include signature of the authority where students initiated their work, or the signature of the authority in whose area students are currently working or photographs of work (photographs must include students working).
5. **Final Report Submission** - Submission of the Testimonials include signatures of the authorities you have worked with, or the signature of the authority in whose area you have worked or photographs of your work (photographs must include you working). Students' accomplishment in their area of operation along with the major successes student experienced and major challenges faced.
6. Students will submit the complete elaborated report along with testimonials and completion certificate in the form of signed Template
7. The registration for all students will open twice, during winter and summer breaks. They may enroll for the internship in either of the two breaks.
8. The student will have to submit a continuous record of their 10 to 15 days internship in the form of photographs and testimonies (wherever required).

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Internal Assessment (Discussion+ Initiating Internship Template)	End Term (Detailed Report Submission + Testimonials Photographs / Student Experience Sharing Video)
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		**Mapped Program Outcomes**
CO1	Understand the concept of social responsibility through an internship.	**PO7, PO10, PO9, PO12**
CO2	Apply hands on experience in 'giving back to the society' through the concept of social responsibility through an internship.	**PO7, PO10, PO9, PO12**

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SOC14100	Community Service	-	-	-	-	-	-	3	-	3	3	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11005	Linear Models	L	T	P	C
Version 1.1	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Knowledge of Linear Algebra				
Co-requisites	--				

Course Objectives:
To introduce the students with the method of least squares and Linear Models both Simple and Multiple Regression Models, ANOVA Models and finally use some tools to test the model validity

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Demonstrate** the concepts of Gauss-Markov set-up
CO2. **Make use of** method of least squares in Simple and Multiple Regression Models.
CO3. **Construct** Analysis of Variance Model to test the significance of several means.
CO4. **Build** model prediction using various statistical tools.

Course Description:

This course is designed to make the students understand the difference between linear and non-linear models. The method of least squares is explained to estimate the parameters of the linear models. The students will be introduced to the analysis of variance models and finally the model validity and prediction using statistical techniques.

Course Content:

Unit I: Gauss-Markov Set-up [10L]
Theory of Linear Estimation, Estimability of linear parametric functions, Method of Least Squares, Gauss-Markov theorem, Estimation of error variance. Fundamental Theorems on Least Squares (statements only), Orthogonal Splitting of total variation, selection of Valid Error.

Unit II: Regression Analysis [15L]
Simple and Multiple Regression analysis. Estimation and Hypothesis Testing in case of Simple and Multiple Regression Models. Tests for Parallelism and Identity, Linearity of Simple Regression. Model checking: Prediction from a fitted model.

Unit III: Analysis of Variance and Covariance [25L]
Definitions of Fixed, Random and Mixed Effect Models, Analysis of Variance and Covariance in One-way classified data for Fixed Effect Models, Analysis of Variance and Covariance (with one concomitant variable) in Two-way classified data with equal number of observations per cell for Fixed Effect Models. Analysis of Variance in One-way classified data for Random Effect Models.

Unit IV: Violations and Binary & Count Data Regression [10L]
Violation of usual assumptions concerning Normality, Homoscedasticity and Collinearity, Diagnostics using quantile-quantile plots, Logistic and Poisson Regression.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.

T2. Goon A.M., Gupta M.K. & Dasgupta B. (2005): An Outline of Statistical Theory, Vol II, The World Press, Kolkata.

Reference Books

R1. Scheffe H. (1959): The Analysis of Variance, John Wiley.

R2. Agresti A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

R3. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** the concepts of Gauss-Markov set-up	PO1, PO4, PO12, PSO1, PSO2
CO2	**Make use of** method of least squares in Simple and Multiple Regression Models.	PO1, PO4, PO6, PSO1, PSO2, PSO3
CO3	**Construct** Analysis of Variance Model to test the significance of several means.	PO1, PO4, PO6, PO8, PSO1, PSO2, PSO3
CO4	**Build** model prediction using various statistical tools.	PO1, PO4, PO12, PSO1, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11005	Linear Models	3	-	-	3	-	3	-	3	-	-	-	2	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12006	Linear Models Practical	L	T	P	C
Version 1.1	**Contact Hours - 45**	0	0	3	2
Pre-requisites/Exposure	Knowledge of Linear Algebra				
Co-requisites	Knowledge of R Programming				

Course Objectives:
To provide students with computing knowledge in fitting Linear Models and interpreting the result

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Find** estimates when X is a full rank and non-full rank matrix.
CO2. **Summarize** Simple and Multiple Linear Regression model.
CO3. **Explain** different Analysis of Variance models.
CO4. **Explain** different Analysis of Covariance models.

Course Description:

This course introduces basic concepts in linear models and their estimation methods. The students will be further introduced to the matrix form of a linear model and hence estimation procedure will be done using matrix algebra. Analysis of variance will be taught which will help the students to perform proper analysis in real life situation. Classes will be conducted by lecture as well as power point presentation, audio visual virtual lab session. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or R Programming)

Sl. No.	Name of the Experiments
1	Estimability when X is a full rank matrix and not a full rank matrix
2	Simple Linear Regression.
3	Multiple Regression.
4	Tests for Linear Hypothesis.
5	Analysis of Variance of a One-way classified data for Fixed Effects Model.
6	Analysis of Variance of a Two-way classified data with one observation per cell for Fixed Effects Model.
7	Analysis of Variance of a Two-way classified data with more than one observation per cell for Fixed Effects Model.
8	Analysis of Covariance of a One-way classified data with one Concomitant variable.
9	Analysis of Covariance of a Two-way classified data with one Concomitant variable.
10	Analysis of Variance of a One-way classified data for Random Effects Model.
11	Logistic and Poisson Regression.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.

T2. Goon A.M., Gupta M.K. & Dasgupta B. (2005): An Outline of Statistical Theory, Vol II, The World Press, Kolkata.

Reference Books

R1. Scheffe H. (1959): The Analysis of Variance, John Wiley.

R2. Agresti A. (2010): Analysis of Ordinal Categorical Data, 2nd Edition, Wiley.

R3. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Find** estimates when X is a full rank and non-full rank matrix.	PO1, PO3, PO5, PSO1, PSO2
CO2	**Summarize** Simple and Multiple Linear Regression model.	PO1, PO4, PO6, PO8, PO12, PSO1, PSO2, PSO3
CO3	**Explain** different Analysis of Variance models.	PO1, PO4, PO6, PO8, PO12, PSO1, PSO2, PSO3
CO4	**Explain** different Analysis of Covariance models.	PO1, PO4, PO6, PO8, PO12, PSO1, PSO2, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12006	Linear Models Practical	3	-	2	3	2	3	-	-	-	-	-	3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11646	Database Management System	L	T	P	C
Version 1.0	Contact Hours -60	3	1	0	4
Pre-requisites/Exposure	Set Theory, Knowledge of programming language.				
Co-requisites	--				

Course Objectives:

1. To understand database concepts, applications, data models, schemas and instances.
2. To implement the relational database design and data modelling using entity-relationship (ER) model.
3. To demonstrate the use of constraints and relational algebra operations.
4. To be able to use SQL in querying the database.
5. To demonstrate Normalization process.
6. To learn the new emerging Technologies and Applications in database.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Describe** the characteristics of database and the architecture of Database system.
CO2. **Model** the elements used in Entity- Relationship diagram.
CO3. **Summarize** relational model concept and illustrate the relational constraints.
CO4. **Build** Structured Query Language (SQL) and apply to query a database.
CO5. **Define** normalization for relational databases.

Course Description:

Databases form the backbone of all applications today – tightly or loosely coupled, intranet or internet based, financial, social, administrative, and so on. Database Management Systems (DBMS) based on relational and other models have long formed the basis for such databases. Consequently, Oracle, Microsoft SQL Server, Sybase etc. have emerged as leading commercial systems while MySQL, PostgreSQL etc. lead in open source and free domain.

While DBMS's differ in the details, they share a common set of models, design paradigms and a Structured Query Language (SQL). In this background the course examines data structures, file organizations, concepts and principles of DBMS's, data analysis, database design, data modeling, database management, data & query optimization, and database implementation. More specifically, the course introduces relational data models; entity-relationship modeling, SQL, data normalization, and database design. Further it introduces query coding practices using MySQL (or any other open system) through various assignments. Design of simple multi-tier client / server architectures based and Web-based database applications is also introduced.

Course Content:

Unit I **[12L]**

DBMS Definition, Characteristics of DBMS , Application and advantages of DBMS, Instances, Schemas and Database States, Three Levels of Architecture , Data Independence, DBMS languages, Data Dictionary, Database Users, Data Administrators.

Unit II **[10L]**

Data Models, types and their comparison, Entity Relationship Model, Entity Types, Entity Sets, Attributes and its types, Keys, E-R Diagram, Data Integrity RDBMS –Concept, Components and Codd's rules.

Unit III **[16L]**

Relational Algebra (selection, projection, union, intersection, Cartesian product, Different types of join like theta join, equi-join, natural join, outer join) Functional Dependencies, Good & Bad Decomposition, Anomalies as a database: A consequences of bad design, Normalization: 1NF, 2NF, 3NF, BCNF, 4NF 5NF.

Unit IV **[22L]**

Introduction to SQL, DDL, DML, and DCL statements, Creating Tables, Adding Constraints, Altering Tables, Update, Insert, Delete & various Form of SELECT- Simple, Using Special Operators for Data Access. Aggregate functions, Joining Multiple Tables (Equi Joins), Joining a Table to itself (self Joins) Functions. Structured Query Language (SQL), Data Definition Language Commands, Data Manipulation Language Commands, Transaction Control Commands, SQL Command.

Text Books

T1. Elmasri, R., & Navathe, S. (2010). Fundamentals of database systems. Addison-Wesley Publishing Company.

T2. Silberschatz, A., Korth, H. F. & Sudarshan, S. Database System Concepts, 6th Edition. McGraw Hill.

T3. Date, C. (2012). Database Design and Relational Theory: Normal Forms and All That Jazz. O'Reilly Media, Inc.

Reference Books

R1. Date, C. J. (2011). SQL and relational theory: How to write accurate SQL code. O'Reilly Media, Inc.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Describe** the characteristics of database and the architecture of Database system.	**PO1, PO2, PO12**
CO2	**Model** the elements used in Entity- Relationship diagram.	**PO3, PO12**
CO3	**Summarize** relational model concept and illustrate the relational constraints.	**PO2, PO12, PSO1**
CO4	**Build** Structured Query Language (SQL) and apply to query a database.	**PO5, PSO1**
CO5	**Define** normalization for relational databases.	**PO4, PO6, PSO1**

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11646	Database Management System	2	2	2	2	2	2	-	-	-	-	-	3	3	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE12647	Database Management System Practical	L	T	P	C
Version 1.0	Contact Hours -45	0	0	3	2
Pre-requisites/Exposure	Set Theory, Knowledge of programming language.				
Co-requisites	--				

Course Objectives:

1. To explain basic database concepts, applications, data models, schemas and instances.
2. To demonstrate the use of constraints and relational algebra operations.
3. To describe the basics of SQL and construct queries using SQL.
4. To emphasize the importance of normalization in databases.
5. To facilitate students in Database design
6. To familiarize issues of concurrency control and transaction management**.**

Course Outcomes:

On completion of this course, the students will be able to

CO1. Organize the basic concepts of Database Systems and Applications.
CO2. Construct the basics of SQL and construct queries using SQL in database creation interaction.
CO3. Define a commercial relational database system (Oracle, MySQL) by writing SQL using the system.

Course Description:

This course introduces the core principles and techniques required in the design and implementation of database systems. This introductory application-oriented course covers the relational database systems RDBMS - the predominant system for business scientific and engineering applications at present. It includes Entity-Relational model, Normalization, Relational model, Relational algebra, and data access queries as well as an introduction to SQL. It also covers essential DBMS concepts such as: Transaction Processing, Concurrency Control and Recovery. It also provides students with theoretical knowledge and practical skills in the use of databases and database management systems in information technology applications.

Course Content:

Experiment 1: Introduction to SQL constructs
Experiment 2: Review of Basic SQL statements
Experiment 3: Creating basic reports
Experiment 4: Program for data access
Experiment 5: Restricting row returns
Experiment 6: Using the set commands
Experiment 7: Joining tables –Equi join
Experiment 8: Joining tables –self join
Experiment 9: Data definition language commands
Experiment 10: Data manipulation language commands
Experiment 11: Transaction control commands
Experiment 12: Writing a subquery, correlated and non-correlated subquery, Non-correlated subqueries
Experiment 13: Advanced SQL operators -Between operator, IN and NOT IN operators, Sub-queries-EXISTS

Text Books:

T1. "Database System Concepts", 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill

T2. "Principles of Database and Knowledge – Base Systems", Vol 1 by J. D. Ullman, Computer Science Press.

Reference Books:

R1. "Fundamentals of Database Systems", 5th Edition by R. Elmasri and S. Navathe, Pearson Education

R2. "Foundations of Databases", Reprint by Serge Abiteboul, Richard Hull, Victor Vianu, Addison-Wesley.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Organize the basic concepts of Database Systems and Applications.	**PO1, PO6, PO12, PSO1**
CO2	Construct the basics of SQL and construct queries using SQL in database creation interaction.	**PO3, PO5, PSO1, PO12**
CO3	Design a commercial relational database system (Oracle, MySQL) by writing SQL using the system.	**PO2, PO9, PSO1, PO4**

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE12647	Database Management System Practical	2	2	2	2	2	2	-	-	-	-	-	3	3	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11035	Discrete Mathematics	L	T	P	C
Version 1.1	Contact Hours - 45	3	0	0	3
Pre-requisites/Exposure	12^{th} level Mathematics				
Co-requisites	--				

Course Objectives:
To develop an in-depth understanding of the Boolean algebra, combinatorics, generating function, Recurrence relation, Graphs and Trees.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Define** the concepts of combinatorics including generating functions.
CO2. **Illustrate** the concept of division algorithm with prime number theory.
CO3. **Explain** the concept of Boolean Algebra.
CO4. **Develop** the idea of graph theory in various mathematical fields.

Course Description:
For any program related to data science Discrete study of Mathematics is very much important. The purpose of this course is to understand and use (abstract) discrete structures and graph theory that are backbones of computer science. In particular, this course is meant to introduce sets, relations, functions, counting, recurrence relation and graphs, with an emphasis on applications in computer science.

Course Content:

Unit I: [15L]
Combinatorics: Sets, Diagonalization and the Pigeonhole Principle, Multinomial theorem, principle of inclusion exclusion; Recurrence relations- classification, summation method, extension to asymptotic solutions from solutions for subsequences; Linear homogeneous relations, characteristic root method, general solution for distinct and repeated roots, non-homogeneous relations and examples, generating functions and their application to linear homogeneous recurrence relations, non-linear recurrence relations, exponential generating functions.

Unit II: [15L]
Basic Number Theory and Boolean Algebra: The Division algorithm: Prime Numbers, The Greatest Common Divisor: Euclidean Algorithm, The Fundamental Theorem of Arithmetic. Boolean Algebra: Boolean Expression and Boolean Function, Identities of Boolean Algebra, Duality, Representation of Boolean Function, Sum-of-Product, Functional Completeness, Switching Function: Disjunctive and Conjunctive Normal Form, Logic Gates, Minimization of Circuits, Boolean Ring.

Unit III: [15L]
Graph Theory: Graphs and digraphs, complement, isomorphism, connectedness and reachability, adjacency matrix, Eulerian paths and circuits in graphs and digraphs, Hamiltonian paths and circuits in graphs and tournaments, trees; Minimum spanning tree, rooted trees and binary trees, planar graphs, Euler's formula, statement of Kuratowski's theorem, dual of a planer graph, independence number and clique number, chromatic number, statement of Four-color theorem, dominating sets and covering sets.

Text Books

T1. Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw – Hill.
T2. C L Liu and D P Mohapatra, Elements of Discrete Mathematics A Computer Oriented Approach, 3rd Edition by, Tata McGraw – Hill.
T3. Susanna S. Epp, Discrete Mathematics with Applications,4th edition, Wadsworth Publishing Co Inc.

Reference Books

R1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structure and It's Application to Computer Science", TMG Edition, Tata McGraw- Hill.
R2. Schaum's Outlines Series, Seymour Lipschutz, Marc Lipson, Discrete Mathematics, Tata McGraw - Hill.
R3. Norman L. Biggs, Discrete Mathematics, 2nd Edition, Oxford University Press.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** the concepts of combinatorics including generating functions.	PO1, PO4, PO12, PSO3
CO2	**Illustrate** the concept of division algorithm with prime number theory.	PO1, PO4, PO12, PSO3
CO3	**Explain** the concept of Boolean Algebra.	PO1, PO4, PO12, PSO3
CO4	**Develop** the idea of graph theory in various mathematical fields.	PO1, PO4, PO12, PSO3, PSO2

Course Code	Course Title	**Academic Excellence** PO1	**Contextualized Understanding** PO2	**Design/development of solutions** PO3	**Conduct investigations of complex problems** PO4	**Quantitative Aspects** PO5	**Modernization and Tools Usage** PO6	**Societal Implication** PO7	**Environment and Sustainability** PO8	**Ethics** PO9	**Individual and Team Work** PO10	**Communication** PO11	**Life Long Learning** PO12	Have the versatility to work effectively in a PSO1	Be familiar with a variety of examples where PSO2	Enhance theoretical rigor with technical skills PSO3
MTH 11035	Discrete Mathematics	3	-	-	3	-	-	-	-	-	-	-	3	-	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS13081	Python for Data Science	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	1	0	3	3
Pre-requisite/Exposure	10+2 Level Mathematics, Knowledge of Basics of Computer				
Co-requisite	NIL				

Course Objectives:

1. To understand the concept of programming using python
2. To apply numerical computations using numpy
3. To apply scientific computations using scipy
4. To visualize trends in data using matplotlib
5. To perform machine learning operations using sklearn

Course Outcomes:

On the completion of this course the student will be able to

CO1. Understand the basic concepts of python
CO2. Apply numerical computation with python
CO3. Compare scientific computation methods with python
CO4. Visualize trends in the data with python
CO5. Implement machine learning models with python.

Course Description:

Data is the new Oil. This statement shows how every modern IT system is driven by capturing, storing and analysing data for various needs. Be it about making decision for business, forecasting weather, studying protein structures in biology or designing a marketing campaign. All of these scenarios involve a multidisciplinary approach of using mathematical models, statistics, graphs, databases and of course the business or scientific logic behind the data analysis. So we need a programming language which can cater to all these diverse needs of data science. Python shines bright as one such language as it has numerous libraries and built in features which makes it easy to tackle the needs of Data science. In this course we will cover these the various techniques used in data science using the Python programming language.

Course Content:

Unit I: **[10L]**

Introduction to Python: Datatypes**, e**xpressions, statements, conditions, loops, classes, objects, functions, data structures, I/O, packages.

DataFrames, Series, loading and saving, alignment, missing data, reshaping, pivoting, slicing, indexing, subsetting, insertion/deletion, merge and join, time series.

Unit II: **[15L]**

Numerical computation: ndarrays, datatypes, mathematical and logical operations, linear algebra, fourier transforms, random, searching, sorting, import and export data.

Unit III: **[12L]**

Scientific computations: Physical and mathematical constants, Fourier transform, Integration routines, Interpolation, Data input and output, Linear algebra routines, Optimization, Signal processing, Sparse matrices, Spatial data structures and algorithms, Any special mathematical functions, Statistics

Unit IV [**15L]**

Data visualization: Chart properties, styling, box plots, heatmaps, scatterplots, bubble charts, 3d charts, time series, geographical data, graph data.

Unit V **[08L]**

Machine Learning: Classification, Regression, Clustering, Dimensionality Reduction, Feature Extraction.

Text Books:

1. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython - Wes McKinney – O'Reilly

2. Machine Learning with Python Cookbook: Practical Solutions from Preprocessing to Deep Learning – Chris Albon- O'reilly

Reference Books:

1. Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas C. Müller, Sarah Guido-O'Reilly

2. Learning Python: Powerful Object-Oriented Programming, Mark Lutz- O'Reilly

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Understand the basic concepts of python	PO1, PO12
CO2	Apply numerical computation with python	PO3, PO5, PO12, PSO3
CO3	Compare scientific computation methods with python	PO1, PO2, PO12, PSO3
CO4	Visualize trends in the data with python	PO3, PO5, PO6, PO12, PSO2, PSO3
CO5	Implement machine learning models with python.	PO3, PO4, PO5, PO6, PO12, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS13081	Python for Data Science	2	1	3	1	3	2	-	-	-	-	-	3	-	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

ECO11031	Macroeconomics	L	T	P	C
Version 1.0	Contact Hours - 90	5	1	0	6
Pre-requisites/Exposure	--				
Co-requisites	--				

Course objectives:

1. To develop fundamentals ideas of macroeconomics.
2. The course will help to learn different theories associated with issues of open as well as closed economies.
3. The course will help to understand the role of money and different theories of inflation.
4. The course should develop idea of output and employment determination in a country.

Course Outcomes:

At the end of the course, the student will be able to:

CO1: Understand various theoretical issues related to an economy.

CO2: Develop ideas about measurement of aggregate macroeconomic variable like savings, investment, GDP and National Income.

CO3: Understand the role of money and different concepts of inflation.

CO4: Understand various alternative theories of output and employment determination in a closed economy in the short run as well as long run and the role of policy in this context.

Course Description:

The objective of the course is to make students understand and analyses how different macroeconomic variables are measured and can shape economic results. The course analyses different macroeconomic concepts and techniques in evaluating business decisions under different situations. Students will be able to understand the terminologies and analytic principles used in macroeconomics and the application of these conceptual tools to several strategic issues. Simple geometry and basic concepts of mathematics will be used in the course of teaching.

Course Content:

Unit 1: Introduction to Macroeconomics and National Income Accounting

Basic issues studied in macroeconomics; measurement of gross domestic product; income, expenditure and the circular flow; real versus nominal GDP; price indices

Unit 2: The Closed Economy in the Short Run

Classical and Keynesian systems; simple Keynesian model of income determination; ISLM model; fiscal and monetary multipliers

Unit 3: Aggregate Demand and Aggregate Supply Curves

Derivation of aggregate demand and aggregate and supply curves; interaction of aggregate demand and supply

Unit 4: Money and Inflation

Functions of money; quantity theory of money; determination of money supply and demand; credit creation; tools of monetary policy, cost push and demand pull inflation

Unit 5: Unemployment and Expectations

Aggregate supply- the Sticky-Price Model, the Imperfect Information Model; Okun's Law; the short-run trade -off between inflation and unemployment; Phillips Curve; Shifts in the Phillips curve; the role of expectation; Natural Rate of unemployment ;The Phillips curve and the Aggregate supply curve; the debate

Text Books:

T1. N. Gregory Mankiw. Macroeconomics, Worth Publishers, 7th edition, 2010
T2. Dornbusch, Fischer and Startz, Macroeconomics, McGraw Hill, 11th edition, 2010
T3. Andrew B. Abel and Ben S. Bernanke, Macroeconomics, Pearson Education, Inc., 7th edition, 2011

Reference Books:

R1. Olivier Blanchard, Macroeconomics, Pearson Education, Inc., 5th edition, 2009
R2. Steven M. Sheffrin, Rational Expectations, Cambridge University Press, 2nd edition, 1996.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO-1	Understand various theoretical issues related to an economy.	**PO1, PO2,PO3, PO7, PO10, PO12**
CO-2	Develop ideas about measurement of aggregate macroeconomic variable like savings, investment, GDP and National Income.	**PO2, PO3, PO4, PO7, PO9, PO10, PO12**
CO-3	Understand the role of money and different concepts of inflation.	**PO4, PO7, PO10, PO12**
CO-4	Understand various alternative theories of output and employment determination in a closed economy in the short run as well as long run and the role of policy in this context.	**PO1, PO2,PO3, PO7, PO10, PO12**

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ECO 11031	MACROECONOMICS	2	2	1	1	-	-	3	-	3	3	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

PHY11024	Elective Physics II	L	T	P	C
Version 1.0	Contact hours-60	3	1	0	4
Pre-requisites/Exposure	Knowledge of Class12 level Physics				
Co-requisites	Basic concept of Differential and Integral Calculus				

Course Objectives

- To understand the principles of kinetic theory of gasses.
- To apply basic postulates of thermodynamics and to understand the first and second law of thermodynamics.
- To analyse different experimental evidence related to the concept of Quantum theory and discuss the development of the subject.
- To apply the knowledge of quantum mechanics to different systems.
- To explore the elementary idea about different theories of statistical mechanics.
- To understand the basic working principle of LASER.
- To understand the structural configuration of different materials.

Course Outcomes

On completion of this course, the students will be able to

CO1. Acquire the basic concepts of kinetic theory of gasses.

CO2. Develop the preliminary concepts of thermodynamics.

CO3. Build up the fundamental knowledge of quantum mechanics and apply it to few simple quantum mechanical systems.

CO4. Gain the elementary idea about the distribution functions of statistical mechanics.

CO5. Develop the basic knowledge of different topics of modern physics like LASER and fibre optics, solid state physics, band theory of solids and magnetism.

Course Description:

Elective Physics II gives an advance overview of modern physics. It deals with the fundamental area of physics in which one can explore a large domain starting from the collective behavior of gas particles, fundamentals of quantum mechanics, solid state physics and many more.

Course Content

1. Kinetic Theory of Gases: 8 Lectures

Maxwell's distribution of molecular velocities (statement only). Calculation of r.m.s, mean and most probable velocities.

2. Thermodynamics: 10 Lectures

Basic concepts: (Thermodynamic system, Surroundings and boundary, Thermodynamic coordinates, State, State function Thermodynamic equilibrium), First law of thermodynamics and its application. Isothermal and adiabatic changes and their relations, indicator diagrams. Reversible and irreversible processes, second law of thermodynamics, Carnot cycle and its efficiency calculation, entropy and its physical interpretation.

3. Quantum Physics: 12 Lectures

Planck's concept of blackbody radiation and radiation formula (statement only), qualitative discussion of photo-electric effect and Compton effect in support of quantum theory, wave-particle duality, Heisenberg uncertainty principle, and Schrödinger equation, particle in a one-dimensional infinite well, energy eigenvalues, wave function and its probabilistic

interpretation. Bohr's theory of hydrogen spectra, concept of quantum number, Pauli Exclusion Principle.

4. Statistical Physics: 12 Lectures

Elementary idea about three distribution functions (Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics), Concepts of Bosons and Fermions.

5. Modern Physics: 18 Lectures

LASER and Fibre Optics, Einstein's A, B coefficient, Population Inversion, He-Ne LASER, Ruby LASER.

Concept of Lattice structure, Bravais Lattice, Free electron theory, Electrical and Thermal conductivity, Band Theory, Elementary idea about Magnetism and Superconductivity.

Reference Books

1. Arthur Beiser, S RaiChoudhury, ShobhitMahajan, (2009), Concept of Modern Physics, 6th Edition, Tata-McGraw Hill.
2. A J Dekker, Solid State Physics, Mcmillan India Ltd, 1st Ed. 2009
3. Thermal Physics, Roy and Gupta
4. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Acquire the basic concepts of kinetic theory of gasses.	**PO1, PO3, PO4**
CO2	Develop the preliminary concepts of thermodynamics.	**PO1,PO3, PO4**
CO3	Build up the fundamental knowledge of quantum mechanics and apply it to few simple quantum mechanical systems.	**PO1, PO2, PO3, PO4, POS3**
CO4	Gain the elementary idea about the distribution functions of statistical mechanics.	**PO1, PO2, PO3, PO4, POS3**
CO5	Develop the basic knowledge of different topics of modern physics like LASER and fibre optics, solid state physics, band theory of solids and magnetism.	**PO1,PO3, PO4**

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PHY11024	Elective Physics II	3	2	1	1											2

1=weakly mapped
2= moderately mapped
3=strongly mapped

PHY12025	Elective Physics II Lab	L	T	P	C
Version 1.0	Contact Hours -30	0	0	2	2
Pre-requisites/Exposure	Knowledge about basic higher secondary physics.				
Co-requisites					

Course Objectives

1. To develop the capability of the students for practical understanding of fundamental aspects of physics.
2. To give students experimental/laboratory-based background, the key prerequisite for performing research near future.
3. To build up real-time idea on basic Newtonian mechanics, general properties of matters, electromagnetic theory and optics. These ideas can upgrade student's understanding in proper channel, so that they can flourish their career path.

Course Outcome:

CO1: Students shall be able to estimate the thermal conductivity of a bad conductor.
CO2: Students shall be able to verify different laws of network theorems of electrical circuits.
CO3: Students shall be able to study of the response of various non-ohmic devices like inductance, capacitance in the electrical circuits.
CO4: Students shall be able to study the characteristic curves of junction diodes and bipolar junction transistors.

Course Description:

This course introduces basic concepts about the experiments related to different domain of physics starting from thermal physics to electrical and electronic devices.

Course Content:

List of Experiments:

1. Determination of thermal conductivity of a bad conductor of heat by Lee's and Charlton's method.

2. To verify the Thevenin and Norton theorem, Superposition theorem, and Maximum Power Transfer theorems.

3. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
4. To study V-I characteristics of PN junction diode, and Light emitting diode.
5. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
6. To study the characteristics of a Bipolar Junction Transistor in CE configuration.

Text Books: Advanced Practical Physics, Volume-I, B. Ghosh & K. G. Mazumdar
Reference Books: An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Class Assessment	End Term
Weightage (%)	50	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO-1	Students shall be able to estimate the thermal conductivity of a bad conductor	PO9, PO10, PO11, PO12
CO-2	Students shall be able to verify different laws of network theorems of electrical circuits.	PO9, PO10, PO11, PO12
CO-3	Students shall be able to study of the response of various non-ohmic devices like inductance, capacitance in the electrical circuits	PO9, PO10, PO11, PO12
CO-4	Students shall be able to study the characteristic curves of junction diodes and bipolar junction transistors	PO9, PO10, PO11, PO12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PHY12025	ELECTIVE PHYSICS LAB II	-	-	-	-	-	-	-	-	3	2	1	1	-	-	-

1=weakly mapped 2= moderately mapped 3=strongly mapped

PSG11021	Human Values and Professional Ethics	L	T	P	C
Version1.0		2	0	0	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

1. To inculcate human values and professional ethics in students.
2. To enhance the understanding of students towards personal, professional & societal relationships and achieve harmony in life.
3. To develop moral responsibilities and ethical vision.

Course Outcomes:

At the completion of the course, the student should be able to:

CO1. Realize the importance of values, ethics, harmony and lifelong learning in personal and professional life
CO2. Apply the knowledge to perform self-exploration and transformation augmenting harmony, peace and positivity in the surroundings.
CO3. Infer core values that shape the ethical behaviour of a professional.

Course Description:

This course aims to develop an understanding for a movement from rule-based society to a relationship-based society. Apart from teaching values, this course encourages students to discover what values are for them and for society. Self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs. It is designed in a way where students get familiar with the Ethical Code of Conduct, Ethical Dilemma, Conflict of Interest and all this will help them eventually in their professional life.

Course Content:

Unit I: Introduction to Human Values:

Character, Integrity, Credibility, Mutual Respect, Dedication, Perseverance, Humility and Perception. Self-Assessment & Analysis, Setting Life Goals, Consciousness and Self-Transformation. Team Work, Conflict Resolution, Influencing and Winning People, Anger Management, Forgiveness and Peace, Morality, Conscience. Yoga and Spirituality

Unit II: Harmony and Life Long Learning:

Harmony in human being, Nature and Existence. Harmony in family and society– Responsibilities towards society, Respecting teachers. Transition from School to College-Freedom & Responsibilities, Respecting Cultural Diversity, Learning beyond the Classrooms, Independent study and research

Unit III: Introduction to Professional Ethics:

Work Ethics, Engineering Ethics, Moral Dilemma, Moral Development Theories, Ethical Theories-Kantinism, Utilitarianism, etc, Case Studies for Choice of the theory, Code of Ethics

Unit IV: Individual to Global Issues:
Industrial Standards, A Balanced Outlook on Law, Safety, Responsibility, Rights, Confidentiality, Conflict of Interest, Occupational Crime, Whistle Blowing, Environmental Ethics, Business Conduct in MNC, E-Professionalism (IPR, Internet Ethics & Privacy issues)

Text Books
Shetty, Foundation Course in Human Values and Professional Ethics [R.R. Gaur, R. Sangal, G.P. Bagaria]

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Realize the importance of values, ethics, harmony and lifelong learning in personal and professional life.	PO9, PO12
CO2	Apply the knowledge to perform self- exploration and transformation augmenting harmony, peace and positivity in the surroundings.	PO7, PO12
CO3	Infer core values that shape the ethical behavior of a professional	PO9, PO12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PSG11021	Human Values and Professional Ethics	-	-	-	-	-	-	2	-	3	-	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11036	Operations Research	L	T	P	C
Version 1.1	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Algebra & Calculus				
Co-requisites	--				

Course Objectives:

- To provide the basic concept of the mathematical model formulation of an optimization problem
- To help the students to learn different methodology for solving Linear Programming Problem
- To enable students to acquire the knowledge of decision-making problems related to transportation, assignment, and rectangular games
- To enable students to acquire the basic knowledge on simulation

Course Outcomes

On completion of this course, the students will be able to

CO1. Make use of different methods for building and solving linear programming model for real-life problems
CO2. Choose appropriate technique for solving Transportation and Assignment problems
CO3. Apply different techniques for solving rectangular games and choose the right strategy
CO4. Explain different concepts of simulation

Course Content:

Unit I **[20L]**

Linear Programming Problem: Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical solutions of a L.P.P. Simplex method for solving L.P.P. Charne's Big-M-method and Two-phase method for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P, Complementary slackness, Dual-simplex method, Primal-Dual Algorithm

Unit II **[12L]**

Transportation Problem: Formulation, Initial basic feasible solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem.

Assignment Problem: Hungarian method to find optimal assignment, special cases of assignment problem.

Unit III **[12L]**

Game Theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy, algebraic method, Simplex method

Unit IV **[16L]**

Simulation: Definition and basic terminologies of simulation, some popular approaches, simulating a coin toss, a die roll and a card shuffle, Random number generation, Methods of generating a random number from different distributions, CDF inversion method, probability integral transformation, Simulating Gaussian distribution using Box-Muller method, Monte Carlo integration, Some real-life applications

Text Books:

T1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Pearson Prentice Hall of India.
T2. Hillier, F. S. &Lieberman, G. J. Introduction to Operations Research. McGraw-Hill Science.

Reference Books:

R1. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13thEdition, Sultan Chand and Sons.
R2. Gupta, P. K. & Hira, D. S. (2007), Operations Research, S. Chand & co.
R3. Raju, N.V.S. Operations Research, SMS Education.
R4. Sharma, S. D. Operations Research: Theory and Applications, 4th edition, Laxmi Publications.
R5. Winston, Wayne L., and Jeffrey B. Goldberg. Operations research: applications and algorithms. Vol. 3. Belmont: Thomson Brooks/Cole, 2004.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Make use of different methods for building and solving linear programming model for real-life problems	PO1, PO2, PO3, PO4, PO5, PO12, PSO1
CO2	Choose appropriate technique for solving Transportation and Assignment problems	PO1, PO2, PO5, PO12, PSO1
CO3	Apply different techniques for solving rectangular games and choose the right strategy	PO1, PO2, PO3, PO4, PO5, PO12, PSO1
CO4	Explain different concepts of simulation	PO1, PO2, PO3, PO4, PO5,PO6, PO12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH11036	Operations Research	2	2	3	3	3	1	-	-	-	-	-	3	3	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11020	Design of Experiments and Multivariate Analysis	L	T	P	C
Version 1.1	**Contact Hours – 60**	3	1	0	4
Pre-requisites/Exposure	Basic Statistics and Probability Distributions				
Co-requisites	Knowledge on Linear Models				

Course Objectives:
To introduce the students with the various techniques in Design of Experiments and Multivariate Analysis which are multipurpose tools used in many situations to optimize the output.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Classify** CRD, RBD, LSD and their analysis.
CO2. **Demonstrate** the applications of Split-Strip Plot Design and Factorial Experiments.
CO3. **Explain** the concepts of Multivariate Data and Random Vectors.
CO4. **Develop** the idea of applications of different Multivariate Distributions.

Course Description:

This course is designed to make the students understand the techniques of design of experiments. The method of least squares is explained to estimate the parameters of the models. The students will be introduced to the analysis of the various models and finally the model validity and prediction will be done using statistical techniques.

Course Content:

Unit I: Experimental and Basic Designs [22L]
Introduction, terminologies: Treatments, Experimental Units & Blocks, Experimental error, Basic principles of Design of Experiments (Fisher). Uniformity trials, fertility contour maps, choice of size and shape of plots and blocks in Agricultural experiments. Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency. Analysis with one missing observation in RBD and LSD.

Unit II: Split Plot & Strip Plot Design and Factorial Experiments [18L]

Split Plot Design in RBD and Strip arrangements. Factorial Experiments: advantages, notations and concepts. 2^n experiments: design and analysis. Total and Partial confounding for 2^n ($n \leq 5$). Factorial experiments in a single replicate.

Unit III: Multivariate Data and Random Vector [12L]
Multivariate Data: Multiple Regression, Multiple and Partial Correlation coefficients. Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions. Multiple and Partial Correlation coefficients. Tests for Multiple and Partial correlation coefficients.

Unit IV: Multivariate Distributions **[08L]**

Multivariate Normal distribution and its properties. Multinomial Distribution and its properties.

Text Books

T1. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics. Vol. I & II, 8th Edn. The World Press, Kolkata.

T2. Montgomery D. C. (2008): Design and Analysis of Experiments, John Wiley.

Reference Books

R1. Kempthorne O. (1965): The Design and Analysis of Experiments. John Wiley.

R2. Das M.N. and Giri N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

R3. Anderson T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		**Mapped POs and PSOs**
CO1	**Classify** CRD, RBD, LSD and their analysis.	PO1, PO4, PO6, PO8, PSO1, PSO2
CO2	**Demonstrate** the applications of Split-Strip Plot Design and Factorial Experiments.	PO4, PO6, PO8, PSO1, PSO2, PSO3
CO3	**Explain** the concepts of Multivariate Data and Random Vectors.	PO4, PO6, PO12, PSO1, PSO2, PSO3
CO4	**Develop** the idea of applications of different Multivariate Distributions.	PO4, PO6, PO12, PSO1, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11020	Design of Experiments and Multivariate Analysis	3	-	-	3	-	3	-	3	-	-	-	3	3	3	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12021	Design of Experiments and Multivariate Analysis Practical	L	T	P	C
Version 1.1	Contact Hours - 45	0	0	3	2
Pre-requisites/Exposure	Basic Statistics and Probability Distributions				
Co-requisites	Knowledge on Linear Models and Microsoft Excel				

Course Objectives:
To introduce the students with the practical techniques of Design of Experiments and Multivariate Analysis which are multipurpose tools used in many situations including agriculture to optimize the output.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Demonstrate** data analysis of CRD, RBD, and LSD
CO2. **Demonstrate** the analysis of Split-Strip Plot Design and Factorial Experiments.
CO3. **Utilize** the various techniques of Multivariate Analysis.
CO4. **Solve** problems using different Multivariate Distributions.

Course Description:
This explains the practical techniques of design of experiments. The analysing techniques will be implemented in Microsoft excel which will help the students to well understand the theory behind the analysis, and hence make them efficient in using programming software. The course instructor will demonstrate the students well to give proper interpretation of the result obtained.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or MS Excel)

Sl. No.	Name of the Experiments
1	Analysis of a CRD.
2	Analysis of an RBD.
3	Analysis of an LSD.
4	Analysis of an RBD with one missing observation.
5	Analysis of an LSD with one missing observation.
6	Analysis of Split Plot and Strip Plot designs.
7	Analysis of $\mathbf{2^2}$ and $\mathbf{2^3}$ Factorial Experiments in CRD and RBD.
8	Analysis of a completely confounded two-level Factorial design in 2 blocks.
9	Analysis of a completely confounded two-level Factorial design in 4 blocks.
10	Analysis of a partially confounded two-level Factorial design.
11	Analysis of a single replicate of a $\mathbf{2^n}$ design.
12	Test for Multiple Correlation.
13	Test for Partial Correlation.
14	Multivariate Normal Distribution.
15	Multinomial Distribution.

Text Books

T1. Goon A.M., Gupta M.K. and Dasgupta B. (2005): Fundamentals of Statistics. Vol. I & II, 8th Edn. The World Press, Kolkata.
T2. Montgomery D. C. (2008): Design and Analysis of Experiments, John Wiley.

Reference Books

R1. Kempthorne O. (1965): The Design and Analysis of Experiments. John Wiley.

R2. Das M.N. and Giri N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

R3. Anderson T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** data analysis of CRD, RBD, and LSD	PO1, PO4, PO6, PO8, PSO1, PSO2
CO2	**Demonstrate** the analysis of Split-Strip Plot Design and Factorial Experiments.	PO4, PO6, PO12, PSO1, PSO2, PSO3
CO3	**Utilize** the various techniques of Multivariate Analysis.	PO4, PO6, PO12, PSO1, PSO2, PSO3
CO4	**Solve** problems using different Multivariate Distributions.	PO4, PO6, PO12, PSO1, PSO2, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12021	Design of Experiments and Multivariate Analysis Practical	3	-	-	3	-	3	--	2	-	-	-	3	3	3	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11650	Introduction to Machine Learning	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	Discrete Mathematics, Differential Calculus, Numerical Methods				
Co-requisite					

Course Objectives:

1. Understand the concepts of machine learning.
2. Understand the clustering techniques and their utilization in machine learning.
3. Study the neural network systems for machine learning.
4. Learn and understand the linear learning models in machine learning.
5. Study the tree-based machine learning techniques and to appreciate their capability.

Course Outcomes:

On the completion of this course the student will be able to

CO1. **List** the various types of machine learning techniques
CO2. **Explain** basic machine learning techniques
CO3. **Compare** classification and clustering techniques
CO4. **Design** modern machine learning techniques
CO5. **Apply** machine learning techniques in various domains

Course Description:

This subject aims to introduce undergraduate students to the world of Machine Learning. This course serves as a first course and expect the learners pile their fundamentals in this field. . The course introduces the motivation for machine learning and other cognitive techniques by different learning methods. It emphasizes on different categories of machine learning like supervised, unsupervised learning. Each of these categories is further described in detail through several problems in each class.

Course Content:

Unit-I [08L]

Overview of Machine Learning – The Landscape. The Learning Problem. Feasibility of Learning. General-to-Specific Hypotheses Ordering. Find-S and Candidate Elimination Algorithm. Version Space and Inductive Bias.
Linear Classification. Linear Regression. Non-linear Transformation. Logistic Regression.

Unit-II [08L]

Bayesian Learning: Probability Overview. MLE and MAP Estimates. Naive Bayes Classifier. Gaussian Naive Bayes Classifier.
Bayesian Networks.
Decision Trees: Decision Tree Representation and Learning Algorithm (ID3). Attribute Selection using Entropy Measures and Gains. Hypotheses Space and Inductive bias. Overfitting, Generalization and Occam's Razor.

Unit-III [14L]

Instance based Learning: k-Nearest Neighbour (kNN) Classifier, Voronoi Diagram and Distance-Weighted kNN. Distance Metrics and Curse of Dimensionality. Computational Complexity: Condensing and High Dimensional Search (kd-tree).

Clustering: Partitional Clustering and Hierarchical Clustering. Cluster Types, Attributes and Salient Features. k-Means, Hierarchical and Density-based Clustering Algorithms. Inter and Intra Clustering Similarity, Cohesion and Separation. MST and DBSCAN Clustering Algorithms.

Unit-IV **[18L]**

Neural Networks: Advanced Topics: Perceptron Learning Algorithm: Delta Rule and Gradient Descent. Multi-layer Perceptron Learning: Backpropagation and Stochastic Gradient Descent. Hypotheses Space, Inductive Bias and Convergence. Variants of Neural Network Structures.
Support Vector Machine: Decision Boundary and Support Vector: Optimization and Primal-Dual Problem. Extension to SVM: Soft Margin and Non-linear Decision Boundary. Kernel Functions and Radial Basis Functions (detailed later).

Unit-V **[12L]**

Applied Machine Learning: Accuracy, Precision, Recall and F-Measures. Scores, Sampling, Bootstraping and ROC. Hypotheses Testing and Cross-validation. Bagging and Boosting. Adaboost and Random Forest. Dimensionality Reduction and Principal Component Analysis (PCA).
Modern Learning Techniques: Reinforcement Learning, Deep Learning, Transfer Learning, Semi-supervised Learning, Active Learning.

Text Books:

1. Machine Learning – Tom M. Mitchell
2. Introduction to Machine Learning - Nils J Nilsson

Reference Books:

1. Pattern Recognition and Machine Learning – Christopher M. Bishop

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**List** the various types of machine learning techniques	PO1, PO12
CO2	**Explain** basic machine learning techniques	PO1, PO2, PO3, PSO3, PO12

CO3	**Compare** classification and clustering techniques	PO1, PO2, PO4, PSO3, PO12
CO4	**Design** modern machine learning techniques	PO1, PO3, PO4, PSO3, PO12
CO5	**Apply** machine learning techniques in various domains	PO1, PO3, PO4, PO6, PO12, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11650	Introduction to Machine Learning	3	2	3	3	-	1	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE12651	Introduction to Machine Learning Practical	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	0	0	2	2
Pre-requisite/Exposure	Discrete Mathematics, Differential Calculus, Numerical Methods				
Co-requisite					

Course Objectives:

1. Understand the concepts of machine learning.
2. Understand the clustering techniques and their utilization in machine learning.
3. Study the neural network systems for machine learning.
4. Learn and understand the linear learning models in machine learning.
5. Study the tree-based machine learning techniques and to appreciate their capability.

Course Outcomes:

On the completion of this course the student will be able to

CO1. **List** the various types of machine learning techniques
CO2. **Explain** basic machine learning techniques
CO3. **Compare** classification and clustering techniques
CO4. **Design** modern machine learning techniques
CO5. Apply machine learning techniques in various domains

Course Description:

This subject aims to introduce undergraduate students to the world of Machine Learning. This course serves as a first course and expect the learners pile their fundamentals in this field. The course introduces the motivation for machine learning and other cognitive techniques by different learning methods. It emphasizes on different categories of machine learning like supervised, unsupervised learning. Each of these categories is further described in detail through several problems in each class.

List of Experiments:

1) Create a scatter plot representation of the IRIS-Dataset using python
2) Calculate co-variance matrix from the features of IRIS-Dataset using python
3) Extract principal components from the IRIS Dataset using python
4) Perform K-Nearest Neighbour Classification using python
5) Implement K-Means Clustering and compare the results of PCA with original features using python
6) Implement backpropagation using python
7) Implement a neural network on the IRIS-dataset using python.
8) Implement the SVM on IRIS-Dataset using LibSVM using python
9) Create an ensemble of classifiers and check accuracy on the IRIS Dataset
10) Write a program in python to implement naïve bayes classifier.
11) Write a program in python to implement ID3 algorithm.
12) Write a program in python to calculate precision recall and f-measure.
13) Implement a neural network to classify the MNIST Dataset
14) Implement a CNN using pytorch to classify the CIFAR Dataset
15) Use cluster validity index to figure out the value of k in k-means algorithm.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**List** the various types of machine learning techniques	PO1, PO6, PO12, PSO3
CO2	**Explain** basic machine learning techniques	PO1, PO6, PO12, PSO3
CO3	**Compare** classification and clustering techniques	PO1, PO4, PO6, PO12, PSO3
CO4	**Design** modern machine learning techniques	PO1, PO4, PO6, PO12, PSO3
CO5	**Apply** machine learning techniques in various domains	PO1, PO4, PO6, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE12651	Introduction to Machine Learning Practical	3	-	-	3	-	3	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11015	Exploratory Data Analysis and Visualization	L	T	P	C
Version 1.1	**Contact Hours - 60**	3	1	0	4
Pre-requisites/Exposure	Knowledge of Statistics & Probability Theory				
Co-requisites	--				

Course Objectives:
To give students the lessons of tools and techniques for solving problems related to exploratory data analysis and visualization, which can be constructed from real life problems.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Define** concept of exploratory data analysis and data visualization, summary statistics, Univariate & multivariate visualization and data abstraction.
CO2. **Illustrate** different types of variables, techniques of interpretation of the data, data import, data cleaning, exploratory graphics of a Financial Dataset & Functional Data and common visualization idioms.
CO3. **Solve** problems related to exploratory data analysis and data visualization.
CO4. **Interpret** the data and summary statistics.
CO5. Explain data summarization and the use of Color & Size in Visualization.
CO6. **Solve** problems related to data abstraction, encoding Data, decision trees, k nearest neighbours.

Course Description:
This course includes exploratory data analysis and data visualization, summary statistics, interpretation of the data, data import, data cleaning, exploratory graphics, data abstraction, encoding Data, decision trees, k nearest neighbours. All the lectures will be devoted on discussions of basic theories and advanced topics, focusing on practical implementation of knowledge. Classes will be conducted by lecture as well as power point presentation, audio visual virtual lab session as per requirement. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

Unit I **[12L]**
Introduction to Data Science, Data Science hype, getting past the hype, Datafication, Current landscape of perspectives, Introduction to exploratory data analysis (EDA) and data visualization, Philosophy of EDA, Basic steps and tools (plots, graphs and summary statistics) of EDA, studying individuals, studying variables, Continuous variables, Discrete variables, Dependency relationships, Multivariate categorical variables, Temporal data, Spatial data,

Unit II **[10L]**
Method of collection and presentation of data, Summary statistics (mean, median, mode, variance, standard deviation), interpreting the data, data import, data cleaning, correspondence analysis.

Unit III **[16L]**

Data visualization introduction, Univariate visualization: quantitative and categorical distributions, Multivariate visualization: interactions between variables, Whole dataset: peeking into high-dimensional spaces, clustering (basics only), projection pursuit, Exploratory Graphics of a Financial Dataset, Visualizing Functional Data.

Unit IV **[22L]**

Data abstraction, Encoding Data with Marks and Channels, Rendering Marks and Channels with D3.js and SVG, common visualization idioms, bar chart, line chart, pie chart, area chart, visualization of spatial data, arranging networks and trees, Decision trees, k nearest neighbors, Using Color and Size in Visualization.

Reference Books

1. F Husson, S Lê, and J Pagès, Exploratory multivariate analysis by example using R. Chapman and Hall/CRC, 2017.
2. J W Tukey, Exploratory data analysis (Vol. 2), 1977.
3. C H Chen, W K Härdle, & A Unwin (Eds.), Handbook of data visualization. Springer Science & Business Media, 2007.
4. van der M Loo, & E de Jonge, Statistical data cleaning with applications in R. John Wiley &Sons, 2018.
5. T W Anderson, An Introduction to Multivariate Statistical Analysis, 3rd Edn. John Wiley, 2003.
6. A H Fielding, Cluster and classification techniques for the biosciences. Cambridge University Press, 2006.
7. B Everitt, & T Hothorn, An introduction to applied multivariate analysis with R. Springer Science & Business Media, 2011.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** concept of exploratory data analysis and data visualization, summary statistics, Univariate & multivariate visualization and data abstraction.	PO1, PSO1, PO12
CO2	**Illustrate** different types of variables, techniques of interpretation of the data, data import, data cleaning, exploratory graphics of a Financial Dataset & Functional Data and common visualization idioms.	PO1, PO3, PSO1
CO3	**Solve** problems related to exploratory data analysis and data visualization.	PO1, PO3, PSO1

CO4	**Interpret** the data and summary statistics	PO1, PO2, PO3, PSO1
CO5	**Explain** data summarization and the use of Color & Size in Visualization.	PO1, PO2, PO12, PSO3
CO6	**Solve** problems related to data abstraction, encoding Data, decision trees, k nearest neighbours.	PO1, PO2, PO5, PO12, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11015	Exploratory Data Analysis and Visualization	3	3	3	-	2	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12083	Exploratory Data Analysis and Visualization Practical	L	T	P	C
Version 1.0	**Contact Hours - 45**	0	0	3	2
Pre-requisites/Exposure	Exploratory Data Analysis theory and basic computer programming concepts				
Co-requisites	--				

Course Objectives:
To provide students' knowledge in programming for statistical techniques in data science using R / R-Studio programming language.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Define** process of creating, extracting data from data frames and reading and writing data and visualization techniques
CO2. **Solve** problems related to model fitting, descriptive statistics & graphics and probability distribution
CO3. **Illustrate** decision trees.
CO4. **Apply** different data visualization techniques on different types of data sets.

Course Description:
This course introduces programming concept in programming for statistical techniques in data science using R / R-Studio programming language. All the lectures will be devoted on discussions of basic theories and advanced topics, focusing on practical implementation of knowledge. Classes will be conducted by lecture as well as power point presentation, audio visual virtual lab session. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

List of Experiments:
(Use R or Python language platform to perform the following experiments)

1. Creating data frames
2. Extracting data from data frames
3. Import and export data files
4. Data cleaning
5. Treatment of missing values
6. Descriptive statistics and graphics
7. Visualization using tools (plots, graphs and summary statistics)
8. Applications based on decision trees
9. Applications on partitioning of graphs
10. Applications based on data visualization techniques

Text Books

T1. Gupta, S. C., & Kapoor, V. K. (1975). *Fundamentals of Mathematical Statistics: A Modern Approach.* S. Chand & Company.
T2. Yau, N. (2011). Visualize this: the Flowing Data guide to design, visualization, and statistics. John Wiley & Sons.

Reference Books

R1. Haider, M. Getting Started with Data Science: Making Sense of Data with Analytics. IBM Press.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Define** process of creating, extracting data from data frames and reading and writing data and visualization techniques	PO1, PO4, PO6, PO12, PSO1, PSO3
CO2	**Solve** problems related to model fitting, descriptive statistics & graphics and probability distribution	PO1, PO3, PO6, PO12, PSO1, PSO3
CO3	**Illustrate** decision trees.	PO1, PO3, PO4, PO6, PO12, PSO1, PSO3
CO4	**Apply** different data visualization techniques on different types of data sets.	PO1, PO3, PO4, PO6, PO12, PSO1, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12083	Exploratory Data Analysis and Visualization Practical	3	-	3	3	-	3	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

ECO11504	Econometrics	L	T	P	C
Version 1.1	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Higher Mathematics				
Co-requisites	--				

Course objectives:

- As this course covers the basics of simple regression for cross-sectional data and emphasizes on intuition, students will be efficient in interpreting the empirical examples.
- The structure of the course makes it ideal for a policy analysis focus.
- Reduce the gap between what is taught in statistics and econometrics text books and how empirical researchers think about and apply econometric methods.

Course Outcomes:

At the end of the course, the student will be able to:

CO1 Apply the statistical theory to the analysis of various numerical data and the estimation of relationships among variables.

CO2 Use statistical techniques for estimating, testing, and forecasting relationships between variables.

CO3 Understand the basic concept of linear regression model under classical assumptions, statistical inference tools and techniques in a regressed model.

CO4 Understand the consequences of violations of classical assumptions

Course Description:

Econometrics is concerned with the application of statistical theory to the analysis of economic data and the estimation of economic relationships. This course intends to expose students to the statistical techniques that are used for estimating, testing, and forecasting economic relationships. In this paper students will be introduced with what 'Econometrics' is about. The basic concept of linear regression model under classical assumptions, statistical inference tools and techniques in a regressed model will be taught in a lucid approach. Moreover, the consequences of violations of classical assumptions will also be taught.

Course Content:

Unit I **[16L]**

Introduction: Objective behind building econometric models, nature of econometrics, model building, role of econometrics, structural and reduced forms, generalized linear model (GLM), Estimation under linear restrictions.

Unit II **[12L]**

Multi-collinearity: Introduction and concepts, detection of multicollinearity, consequences, tests and solutions of multicollinearity, specification error.

Unit III **[17L]**

Generalized least squares estimation, Aitken estimators. Autocorrelation: concept, consequences of auto-correlated disturbances, detection and solution of autocorrelation, Heteroscedastic disturbances, Consequences of heteroscedasticity, Tests and solutions of heteroscedasticity.

Text Books

T1. Gujarati, D. and Sangeetha, S. (2007): Basic Econometrics, 4th Edition, McGraw Hill Companies

T2. Maddala, G.S. and Lahiri, K. (2009): Introduction to Econometrics, 4th Edition, Wiley & Sons.

Reference Books

R1. Johnston J. & Dinardo J. (1997): Econometric Methods. McGraw Hill

R2. Wooldridge, J. M.: Introductory Econometrics: A Modern Approach. Cengage Learning.

R3. Heckman, J. J. & Leamer E. E.: Handbook of Econometrics. Elsevier.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Apply the statistical theory to the analysis of various numerical data and the estimation of relationships among variables.	PO1, PO3, PO6, PO8, PO12
CO2	Use statistical techniques for estimating, testing, and forecasting relationships between variables.	PO1, PO3, PO6, PO8, PO10, P12
CO3	Understand the basic concept of linear regression model under classical assumptions, statistical inference tools and techniques in a regressed model.	PO1, PO3, PO6, PO8, PO10, P12
CO4	Understand the consequences of violations of classical assumptions	PO3, PO6, PO8, PO10, P12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ECO11504	Econometrics	2	-	2	-	-	3	-	3	-	3	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11086	Statistical Quality Control	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Basic knowledge of Applied Statistics				
Co-requisites	--				

Course Objectives:
To provide students with an exposure to the applications Statistical Quality Control in the industry.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Classify** the introductory concepts of a Statistical Quality Control process.
CO2. **Analyze** various Variable and Attribute Control Charts to comment on the state of control of a given production process.
CO3. **Make use of** the knowledge of Single and Double Sampling Inspection Plans for Attributes.
CO4. **Explain** the concepts of Six-Sigma and ISO quality standards.

Course Description:
This course will help students to get acquainted with terminologies of Statistical Quality Control and develop idea about several control charts to inspect a production process. Various sampling inspection plans will be discussed for their appropriate implementation. Some standards will be explained. All these will help students to get a complete overview regarding the quality control of any production setup.

Course Content:

Unit I: Quality [10L]
Definition, dimensions of Quality, Difference between Product Control and Process Control, Statistical Process Control - Seven tools of SPC, Chance and Assignable Causes of quality variation.

Unit II: Statistical Control Charts [20L]
Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping, Control charts for Variables: X-bar & R-chart, X-bar & S-chart. Control charts for Attributes: np chart, p-chart, c-chart and u-chart. Comparison between Control Charts for Variables and Control Charts for Attributes. Analysis of patterns on Control Chart. Estimation of Process Capability.

Unit III: Product Control [20L]
Definitions related to Product Control, Acceptance Sampling Plan, Principle of Acceptance Sampling Plans, Single Sampling Plan - their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, Double Sampling Plan - their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphical interpretation, use and interpretation of Dodge and Romig Sampling Inspection Plan tables.

Unit IV: Six-Sigma and ISO quality standards [10L]
Introduction to Six-Sigma: Overview of Six-Sigma, Lean Manufacturing and Total Quality Management (TQM). Introduction to ISO quality standards: ISO 9001, ISO 14001, BIS.

Text Books

T1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn., The World Press, Kolkata

T2. Montogomery D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

Reference Books

R1. Mukhopadhyay P. (2011): Applied Statistics, 2nd edition revised reprint, Books and Allied (P) Ltd.

R2. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

R3. Hoyle David (1995): ISO Quality Systems Handbook, Heinemann Publication. 2nd Edition, Butterworth

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Classify** the introductory concepts of a Statistical Quality Control process.	PO1, PO12
CO2	**Analyze** various Variable and Attribute Control Charts to comment on the state of control of a given production process.	PO3, PO5, PO6, PO12, PSO2
CO3	**Make use of** the knowledge of Single and Double Sampling Inspection Plans for Attributes.	PO4, PO5, PO6, PO12, PSO2
CO4	**Explain** the concepts of Six-Sigma and ISO quality standards.	PO5, PO12

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11086	Statistical Quality Control	2	-	2	2	3	3	-	-	-	-	-	3	-	3	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11038	Soft Computing	L	T	P	C
Version 1.0	**Contact Hours - 60**	3	1	0	4
Pre-requisites/Exposure	Set theory and logics				
Co-requisites	--				

Course Objectives:
To acquire the basic notion of fuzzy set theory, fuzzy logic, artificial neural network, evolutionary algorithm and rough set theory and their applications to the real-world decision-making problems.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Explain** the notion of fuzzy set and fuzzy logic, and define several operations of fuzzy sets, fuzzy numbers.
CO2. **Illustrate** the basic concept of neural networks and define neuro-fuzzy systems.
CO3. **Find** the best solution of optimization problems by using evolutionary algorithms.
CO4. **Analyse** the hybrid soft computing techniques- Neuro-Fuzzy Hybrid Systems, Genetic Neuro-Hybrid Systems.

Course Description:
The notion of a fuzzy set provides a convenient point of departure for the construction of a conceptual frame-work which parallels in many respects the framework used in the case of ordinary sets, but is more general than the crisp set. Fuzzy set theory provides a strict mathematical framework in which vague conceptual phenomena can be precisely and rigorously studied. This course provides possible hybrid combinations with other intelligent algorithms, especially neural network and genetic algorithms. It introduces rough sets which are applied to process imprecise, uncertain and incomplete data. The key thinking of the rough set theory is to make use of the known knowledge database, and depict roughly the imprecise or uncertain knowledge with the help of the known knowledge in the knowledge database.

Course Content:

Unit I
Soft Computing: Introduction, requirement, different tools and techniques, usefulness and applications.
Fuzzy Sets And Fuzzy Logic: Basic concepts of fuzzy set theory, crisp sets vs fuzzy set, operations on fuzzy sets, extension principle, fuzzy relations and relation equations, fuzzy numbers, linguistic variables, classical logic, multivalued logic, fuzzy propositions, fuzzy quantifiers, linguistic hedges, inference schemes. Applications: Fuzzy Controllers, Fuzzy Pattern Recognition. **[18L]**

Unit II
Artificial Neural Network: Introduction, basic models, Hebb's learning, Adaline, perceptron, multilayer feed forward network, back propagation, convergence of multilayer perceptron, competitive learning, self-organizing feature maps, adaptive resonance theory, associative memories, applications. **[16L]**

Unit-III

Evolutionary And Stochastic Techniques: Genetic Algorithm (GA), GA Operators, Analysis Of Selection Operations, Hypothesis Of Building Blocks, Schema Theorem And Convergence Of Genetic Algorithm, Simulated Annealing And Stochastic Models, Boltzmann Machine, Applications. **[14L]**

Unit-IV

Hybrid Systems: Neural-network-based fuzzy systems, fuzzy logic-based neural networks, genetic algorithm for neural network, fuzzy logic and genetic algorithm for optimization, applications. **[12L]**

Text Books:

T1. S.N. Sivanandam, S.N. Deepa, Principles of Soft Computing, Willey.

T2. S. Rajsekharan and V. Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, Synthesis and Applications, PHI Learning.

Reference Books:

R1. D. E. Goldberg and Addison wesley , Genetic Algorithms in Search And Optimization, and Machine Learning, 1989.

R2. Fuzzy sets and systems: theory and applications, D. Dubois, H. Prade, Academic Press, Inc. 1997.

R3. Chin-Teng Lin and C. S. George Lee, Neural Fuzzy Systems, Prentice Hall PTR.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Explain** the notion of fuzzy set and fuzzy logic, and define several operations of fuzzy sets, fuzzy numbers.	PO4, PO12, PSO1, PSO3
CO2	**Illustrate** the basic concept of neural networks and define neuro-fuzzy systems.	PO4, PO6, PO12, PSO3
CO3	**Find** the best solution of optimization problems by using evolutionary algorithms.	PO6, PO12, PSO1, PSO3
CO4	**Define** the rough set and process the imprecise, uncertain and incomplete data by applying rough set.	PO4, PO12, PSO1, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH 11038	Soft Computing	-	-	-	3	-	3	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11659	Design and Analysis of Algorithms	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	Discrete Mathematics				
Co-requisite	NIL				

Course Objectives:

1. To introduce problem solving approach through design.
2. To develop students to analyse the existing algorithms and approach for improvement.
3. To introduce the students a perspective to different design and analysis approach for algorithm(s) to solve a problem.
4. To develop students to select optimal solution to a problem by choosing the most appropriate algorithmic method.

Course Outcomes:

On the completion of this course the student will be able to

CO1. Understand the basics about algorithms and learn how to analyse and design algorithms
CO2. Choose brute force, divide and conquer, dynamic programming and greedy techniques methods to solve computing problems
CO3. Understand the approach for solving problems using iterative method
CO4. Describe the solution of complex problems using backtracking, branch and bound techniques
CO5. Classify the different Computability classes of P, NP, NP-complete and NP-hard.

Course Description:

Algorithmic study is a core part of Computer Science. This study caters to all possible applicable areas of Computer Science. This study includes observation, design, analysis and conclusion. Various types of algorithms have different notion of implementation according to their cost (in terms their time and space complexity). This study also includes refinement of one algorithm as per the applicability to real problems. Categorization of algorithms according to different method of design also includes in this course. It also compares the same algorithm using different algorithm design methods. For example, Knapsack problem can be solved in Greedy approach and Dynamic approach, both are optimization method. This course enables the students to think analytically while applying, designing an algorithm to solve a specific problem.

Course Content

Unit-I [12L]

Introduction:

Characteristics of algorithm. Analysis of algorithm: Asymptotic analysis of complexity bounds – best, average and worst-case behaviour; Performance measurements of Algorithm, Time and space trade-offs, Analysis of recursive algorithms through recurrence relations: Substitution method, Recursion tree method and Masters' theorem.

Algorithm Design Paradigms.

Unit-II [12L]

Sorting Algorithms & Data Structures:

Selection sort, bubble sort, insertion sort, Sorting in linear time, count sort, Linear search,

Divide & Conquer:

Quick sort, worst and average case complexity, Merge sort, Matrix multiplication

Binary search, Binary search tree, Strassen's algorithm for matrix multiplication, The substitution method for solving recurrences, The recursion-tree method for solving recurrences, The master method for solving recurrences.

Unit-III [12L]

Greedy algorithms:

General Characteristics of greedy algorithms, Problem solving using Greedy Algorithm- Activity selection problem, Minimum Spanning trees (Kruskal's algorithm, Prim's algorithm), Graphs: Shortest paths, The Knapsack Problem

Dynamic programming:

Introduction, The Principle of Optimality, Problem Solving using Dynamic Programming- Making Change Problem, Assembly Line Scheduling, Knapsack problem, Matrix chain multiplication, Longest Common Subsequence Dynamic Programming using Memoization.

Unit-IV [12L]

Graph Algorithms:

Representations of graphs, Breadth-first search, Depth-first search, Topological sort, Strongly connected components, Minimum Spanning Trees, Growing a minimum-spanning tree, The algorithms of Kruskal and Prim, Single-Source Shortest Paths, Bellman-Ford algorithm, Single-source shortest paths in directed acyclic graphs, Dijkstra's algorithm, Difference constraints and shortest paths, Proofs of shortest-paths properties, All-Pairs Shortest Paths, Shortest paths and matrix multiplication, The Floyd-Warshall algorithm, Johnson's algorithm for sparse graphs, Maximum Flow, Flow-networks, The Ford-Fulkerson method,

Branch & Bound & Backtracking

Unit-V [12L]

String Matching

The naive string-matching algorithm, The Rabin-Karp algorithm, String matching with finite automata, The Knuth-Morris-Pratt algorithm

Approximation Algorithms:

The vertex-cover problem, the traveling-salesman problem, the set-covering problem, Randomization and linear programming

NP-Completeness:

Polynomial time, Polynomial-time verification, NP-completeness and reducibility,

NP-completeness proofs, NP-complete problems.

Text Books:

T1. Introduction to Algorithms, 4TH Edition, Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, MIT Press/ Mcgraw-Hill

T2. Fundamentals of Algorithms – E. Horowitz Et Al

T3. Algorithm Design, 1ST Edition, Jon Kleinberg and Évatardos, Pearson

Reference Books:

R1. Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition, Michael T Goodrich and Roberto Tamassia, Wiley

R2. Algorithms -- A Creative Approach, 3RD Edition, Udimanber, Addison-Wesley, Reading, MA.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Understand the basics about algorithms and learn how to analyze and design algorithms	PO3, PO12
CO2	Choose brute force, divide and conquer, dynamic programming and greedy techniques methods to solve computing problems	PO5, PO12, PSO3
CO3	Understand the approach for solving problems using iterative method	PO3, PO5, PO12, PSO3
CO4	Describe the solution of complex problems using backtracking, branch and bound techniques	PO3, PO5, PO12, PSO3
CO5	Classify the different Computability classes of P, NP, NP-complete and NP-hard.	PO5, PO12

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11659	Design and Analysis of Algorithms	-	-	3	-	3	-	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS14039	Summer Internship	L	T	P	C
Version 1.0		-	-	-	2
Pre-requisites/Exposure	All Statistics & Data Analytics subjects				
Co-requisites	--				

Course Objectives:
To apply the theory of Statistics and Data Science in relevance to practical solutions

Course Outcomes
On completion of this course, the students will be able to

CO1. Understand the professional requirements for access to and success in the field.
CO2. Apply techniques using different methods of applying skills and knowledge acquired in the classroom.
CO3. Discover the work ethic and skills required for success in the field.

Course Description:
Summer internship gives the student an opportunity to bridge theoretical knowledge in practical applications. It is a learning experience that permits students to apply knowledge acquired in the academic classroom within the professional setting. Such experiential learning supplements academic theory, helps the student to identify personal strengths and guides her/him into specialized fields within the profession (Engineering, site works, marketing, media relations, financial management, etc.). Perhaps equally as important is the chance for the student to begin to establish the professional network so essential for access to, and movement within, the profession. The student may personally research internship opportunities and interview for any opportunity that furthers the student's professional aspirations in the field.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Attendance	Presentation	Report of Training	Viva
Weightage (%)	10	40	40	10

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	Understand the professional requirements for access to and success in the field.	PO1, PO6, PO9, PSO2
CO2	Apply techniques using different methods of applying skills and knowledge acquired in the classroom.	PO3, PO6, PO9, PSO2
CO3	Discover the work ethic and skills required for success in the field.	PO9, PO10, PSO2

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS14039	Summer Internship	2	-	2	-	-	3	-	-	3	2	-	-	-	3	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11084	An Introduction to Data Mining	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Knowledge of Probability and probability distributions				
Co-requisites	--				

Course Objectives:
To develop the concept of data mining, origin, techniques with real life applications problems. We study the Naïve algorithm, Apriori algorithm, Bayesian classification, rule-based classification, linear and nonlinear Regression.

Course Outcomes
On completion of this course, the students will be able to

CO1. **Make use of** the concept of data mining and applications with descriptive data summarization, central tendency, dispersion measure and data cleaning
CO2. **Illustrate** the Market-basket analysis basics, Naïve algorithm, Apriori algorithm and Bayesian classification
CO3. **Explain** the cluster analysis and partitioning, Hierarchical and density-based methods
CO4. **Demonstrate** the principal component analysis and factor analysis with real-life situation.

Course Description:
This course includes order statistics and related distributions, estimation theory, statistical hypothesis testing and exact sampling distribution and its applications. All the lectures will be devoted on discussions of basic theories and advanced topics, focusing on practical implementation of knowledge. Classes will be conducted by lecture as well as power point presentation, audio visual virtual lab session as per requirement. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:
Unit I: Concept of data mining with applications: [18L]
Introduction: Data Mining Concept, Origin, Process, Applications, Techniques, Challenges Data Pre-processing, Data types, Quality, Descriptive data summarization, central tendency and dispersion measure, Data cleaning, Data integration & transform, Data reduction.

Unit II: Association Rule Mining with Classification and Prediction [17L]
Association Rule Mining: Market-basket analysis basics, Naïve algorithm, Apriori algorithm, Direct Hashing and Pruning (DHP), Software for Association Rule Mining Classification and Prediction: Decision Tree, Classification by decision tree induction, Bayesian classification, Rule-based classification, Prediction – Linear and Nonlinear Regression.

Unit III: Cluster analysis [15L]
Classification software Cluster Analysis: Types of data in cluster analysis, Partitioning methods, Hierarchical methods, Density-based methods, Quality & Validity of clustering methods Cluster analysis software.

Unit IV: Dimension reduction techniques [10L]
Introduction to Principal Component Analysis (PCA) and Factor Analysis. Simple Applications related to real-life situations.

Text Books

T1. T1. Cielen, D., Meysman, A. D. B. & Ali, M. Introducing Data Science: Big Data, Machine Learning, and more, using Python tools. Manning Publications Co., USA.

T2. Han, J., Pei, J., & Kamber, M. (2011). Data mining: concepts and techniques. Elsevier.

Reference Books

R1. Michalski, R. S., Carbonell, J. G., & Mitchell, T. M. (Eds.). (2013). Machine learning: An artificial intelligence approach. Springer Science & Business Media.

R2. Simsion, G., & Witt, G. (2004). Data modeling essentials. Elsevier.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Make use of** the concept of data mining and applications with descriptive data summarization, central tendency, dispersion measure and data cleaning	PO1, PO2, PO12, PSO1, PSO3
CO2	**Illustrate** the Market-basket analysis basics, Naïve algorithm, Apriori algorithm and Bayesian classification	PO1, PO2, PO3, PO4, PO12, PSO1, PSO3
CO3	**Explain** the cluster analysis and partitioning, Hierarchical and density-based methods	PO1, PO2, PO3, PO4, PO12, PSO1, PSO3
CO4	**Demonstrate** the principal component analysis and factor analysis with real-life situation.	PO1, PO2, PO3, PO4, PO12, PSO1, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11084	An Introduction to Data Mining	3	3	3	3	-	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12085	An Introduction to Data Mining Practical	L	T	P	C
Version 1.0	Contact Hours - 45	0	0	3	2
Pre-requisites/Exposure	Statistics and basic computer programming concepts				
Co-requisites	--				

Course Objectives:

To develop the concept of descriptive data summarization, central tendency with practical application of data cleaning. We will study practical based on data integration, data transformation, association rule mining classification and prediction problem. Also, we learn the linear and non-linear regression and cluster analysis, partitioning methods with their real-life applications problems.

Course Outcomes

On completion of this course, the students will be able to

CO1. **Develop** the practical concept of descriptive data summarization, central tendency and dispersion measure

CO2. **Make use of** the practical application of data cleaning, data integration and data transformation

CO3. **Illustrate** the association rule mining classification and prediction, and practical on decision trees

CO4. **Demonstrate** the cluster analysis, principal component analysis, and factor analysis with a real-life situation.

Course Description:

This course introduces programming concept in programming for statistical techniques in data analytics and data mining using R / R-Studio programming language. All the lectures will be devoted on discussions of basic theories and advanced topics, focusing on practical implementation of knowledge. Classes will be conducted by lecture as well as power point presentation, audio visual virtual lab session. The tutorials will familiarize the students with practical problem-solving techniques led by the course coordinator. Students will strongly grab the basic concepts of the subject via exercise and discussions with the coordinator.

Course Content:

List of Experiments:

(Use R or Python language platform to perform the following experiments)

1. Descriptive data summarization
2. Central tendency
3. Dispersion measure
4. Practical application of Data cleaning
5. Practical based on Data integration and data transformation
6. Association Rule Mining Classification and Prediction
7. Practical on decision trees
8. Linear and non-linear regression
9. Cluster analysis, partitioning methods
10. Simple Applications related to Principal Component Analysis (PCA)
11. Factor Analysis

Text Books

T1. Cielen, D., Meysman, A. D. B. & Ali, M. Introducing Data Science: Big Data, Machine Learning, and more, using Python tools. Manning Publications Co., USA.

T2. Simsion, G., & Witt, G. (2004). Data modeling essentials. Elsevier.

Reference Books

R1. Michalski, R. S., Carbonell, J. G., & Mitchell, T. M. (Eds.). (2013). Machine learning: An artificial intelligence approach. Springer Science & Business Media.

R2. Han, J., Pei, J., & Kamber, M. (2011). Data mining: concepts and techniques. Elsevier.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Develop** the practical concept of descriptive data summarization, central tendency and dispersion measure	PO1, PO5, PO6, PO12,
CO2	**Make use of** the practical application of data cleaning, data integration and data transformation	PO1, PO5, PO6, PO12,
CO3	**Illustrate** the association rule mining classification and prediction, and practical on decision trees	PO1, PO5, PO6, PO12,
CO4	**Demonstrate** the cluster analysis, principal component analysis, and factor analysis with a real-life situation.	PO1, PO5, PO6, PO12,

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12085	An Introduction to Data Mining Practical	3	-	-	-	3	3	-	-	-	-	-	3	-	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11081	INTRODUCTION TO DECISION SCIENCE	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Probability and Operations Research				
Co-requisites	--				

Course Objectives:

1. To develop the knowledge of decision theory which will help the student to take decision scientifically
2. To understand different terminologies of multi-criterion decision making and its methods
3. To build the knowledge of project management
4. To understand the concepts related to the information theory

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Solve** decision making problems scientifically
CO2. **Explain** different terminologies of a multi-criteria decision-making problem
CO3. **Apply** PERT and CPM to manage project efficiently
CO4. **Illustrate** different concepts of Information theory

Course Description:

Students will be able to understand and implement several decision-making processes. They will acquire knowledge regarding several decision environments. Several approaches under multiple criteria towards decision making will be explained through examples. Relevant techniques regarding implementation of PERT and CPM will help students to understand and act upon real life problems. Entropy function will be elaborated to give students an idea regarding information science.

Course Content:

Unit-I

Decision theory and decision trees: Introduction, steps of decision-making process, types of decision-making environments, decision-making under uncertainty, optimism (Maximax or Minimin) criterion, pessimism (maximin or minimax) criterion, equal probabilities (Laplace) criterion, coefficient of optimism (Hurwicz) criterion, regret (savage) criterion.

Decision-making under risk: Expected monetary value (EMV), expected opportunity loss (EOL), expected value of perfect information (EVPI), posterior probabilities and Bayesian analysis, decision trees analysis, decision-making with utilities, utility equations, utility curve, and construction of utility curves. **[18L]**

Unit-II

Multiple Criteria Decision Making (MCDM): Terms for MCDM environment, MCDM solutions, the concept of "Best Solution", criteria normalization, computing criteria weights, multi-attribute decision making (MADM), multi-objective decision making (MODM), methods for MADM, simple additive weighting method, hierarchica1 additive weighting method, ELECTRE method, TOPSIS, methods for MODM. [**18L**]

Unit-III

Project Management: PERT and CPM, basic differences between PERT and CPM, significance of using PERT, CPM, phases of project management, PERT and CPM network

components and precedence relationships, rules for AOA network construction, errors and dummies in network, critical path analysis. [**14L**]

Unit-IV

Information Theory: Introduction, communication processes, memory less channel, the channel matrix, probability relation in a channel, noiseless channel, a measure of information-entropy function, marginal and joint entropies, conditional entropies, expected mutual information, axiom of an entropy function, basic requirements of logarithmic entropy functions. [**10L**]

Text Books:

T1. Hamdy A. Taha, Operations Research: An Introduction, 8th Ed., Prentice Hall India, 2006.
T2. A. Ravi Ravindran, Operations Research Methodologies, Taylor & Francis Group, LLC, 2009.

Reference Books:

R1. C. Hwang, K. Yoon, Multiple Attribute Decision Making Methods and Applications: A State-of-the-Art Survey, Springer-Verlag Berlin Heidelberg New York, 1981.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Solve** decision making problems scientifically	PO3, PO4, PO5, PO12
CO2	**Explain** different terminologies of a multi-criteria decision-making problem	PO1, PO2, PO3, PO12, PSO2
CO3	**Apply** PERT and CPM to manage project efficiently	PO5, PO6, PO12, PSO2, PSO3
CO4	**Illustrate** different concepts of Information theory	PO1, PO2, PO12

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH 11081	INTRODUCTION TO DECISION SCIENCE	3	3	3	2	3	2	-	-	-	-	-	3	-	3	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11087	Demography and Survival Analysis	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Basic knowledge of Applied Statistics and Probability Distributions				
Co-requisites	--				

Course Objectives:

- To introduce the students with the different methodologies of handling data on Demography & Vital Statistics.
- To make the students aware about the real-life applications of Survival Analysis and Competing Risk Theory.

Course Outcomes:

On completion of this course, the students will be able to

CO1. **Demonstrate** the introductory concepts of Vital Statistics and Measurements of Mortality.
CO2. **Develop** concepts of Life Tables and different measures of Fertility & Population Growth.
CO3. **Build** knowledge about the Survival distributions and different Censoring schemes.
CO4. **Explain** the concepts of Competing Risk Theory and its real-life applications.

Course Description:

This course enables students to understand fundamentals of population studies. This will help them to apprehend concepts such as fertility, mortality, etc. Various survival distributions along with different censoring approaches will be elaborated to provide insights regarding real life problems.

Course Content:

Unit I: Introduction to Demography and Measurements of Mortality [15L]

Introduction: Sources of data on Vital Statistics, errors in Census and Registration data. Measurement of population, Rates and Ratios of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Standardized Death Rate, Cause of Death Rate, Case Fatality Rate, Infant Mortality Rate (IMR), Maternal Mortality Rate (MMR), Neonatal and Perinatal Mortality Rates.

Unit II: Life Tables and Measurements of Fertility & Population Growth [15L]

Life (Mortality) Tables: Assumption, descriptions of Complete and Abridged Life Tables, Cohort vs. Current Life Tables, Stationary and Stable population, Construction of Complete Life Table from population and death statistics, Central Mortality Rates and Force of Mortality, Uses of Life Tables. Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rate of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Unit III: Survival Analysis [20L]

Introduction, Functions of Survival times, Survival distributions and their applications - Exponential, Gamma, Weibull, Rayleigh, Lognormal distributions and distribution having bath-tub shaped hazard function. Mean Residual Time. Censoring Schemes: Type I, Type II and Progressive or Random Censoring with biological examples. Estimation of mean survival

time and variance of the estimator for Type I and Type II censored data with numerical examples. Non-parametric methods: Actuarial and Kaplan-Meier methods for estimating survival function and variance of the estimator.

Unit IV: Competing Risk Theory **[10L]**

Indices for measurement of probability of death under Competing Risks and their interrelations. Estimation of probabilities of death using maximum likelihood principle and modified minimum Chi-square methods.

Text Books

T1. Goon A.M., Gupta M.K. & Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn. The World Press, Kolkata.

T2. D. J. Kleinbaum and M. Klein (2012): Survival Analysis – A Self Learning Text, 3rd Edn. Springer.

Reference Books

R1. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied (P) Ltd.

R2. J. P. Klein and M. L. Moeschberger (2003): Techniques of Censored and Truncated Data, 2nd Edn. Springer.

R3. Lee E.T. and Wang J.W. (2003): Statistical Methods for Survival data Analysis, 3rd Edition, John Wiley and Sons.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Demonstrate** the introductory concepts of Vital Statistics and Measurements of Mortality.	PO1, PO7, PO12, PSO2
CO2	**Develop** concepts of Life Tables and different measures of Fertility & Population Growth.	PO1, PO3, PO7, PO12, PSO2
CO3	**Build** knowledge about the Survival distributions and different Censoring schemes.	PO4, PO5, PO7, PO12, PSO2
CO4	**Explain** the concepts of Competing Risk Theory and its real-life applications.	PO4, PO5, PO7, PO12, PSO2

Course Code	Course Title	PO1 Academic Excellence	PO2 Contextualized Understanding	PO3 Design/development of solutions	PO4 Conduct investigations of complex problems	PO5 Quantitative Aspects	PO6 Modernization and Tools Usage	PO7 Societal Implication	PO8 Environment and Sustainability	PO9 Ethics	PO10 Individual and Team Work	PO11 Communication	PO12 Life Long Learning	PSO1 Have the versatility to work effectively in a	PSO2 Be familiar with a variety of examples where	PSO3 Enhance theoretical rigor with technical skills
SDS11087	Demography and Survival Analysis	3	-	2	3	3	-	3	-	-	-	-	3	-	3	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11652	Introduction to Big Data	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	Basic Mathematics				
Co-requisite					

Course Objectives:

1. To make students familiar with cloud computing
2. To enable students to know and conceptualize Big Data
3. To enhance the skill of solving Big Data problems

Course Outcomes:

On the completion of this course the student will be able to

CO1. **Understand** the fundamentals of Cloud Computing
CO2. **Evaluating** the concept of Big Data
CO3. **Explain** different Big Data Framework
CO4. **Explain** different cloud computing storage and architectures
CO5. **Apply** big data application

Course Description:

The course presents an overview of cloud computing in the context of its architecture and storage modules. Its main focus is on parallel programming techniques for cloud computing and large-scale distributed systems that form the cloud infrastructure. The topics include Overview of Cloud Computing, Introduction to Big Data, Big Data Frameworks, Cloud Architectures and Storage Systems and Deployment of Massive Datasets over cloud. Students will study the concept of Big Data, different frameworks to solve Big Data problems. Students will also be able to learn how to deploy massive datasets over cloud using different cloud computing tools and to analyse it.

Course Content:

Unit-I [08L]

Introduction to Big Data Big Data Definition, Characteristic Features, Structure, Applications - Big Data vs Traditional Data - Risks of Big Data - Challenges of Conventional Systems - Web Data – Evolution of Analytic Scalability - Evolution of Analytic Processes, Tools and methods - Analysis vs Reporting - Modern Data Analytic Tools.

Unit-II [08L]

Big Data Frameworks Apache Hadoop, MapReduce, Apache Spark, Hadoop Yarn, Large-Scale File System Organization – Master-Slave/Master-Worker Architecture– HDFS concepts – MapReduce Execution, Matrix-Vector Multiplication , Concept of Apache Pig and Apache Hive

Unit-III [14L]

Overview of Cloud Computing Introduction, Definition and evolution of Cloud Computing; Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Cases; Benefits, Risks, and Challenges of Cloud Computing Economic Models and SLAs. Contrast traditional software development and development for the cloud. Public v private cloud apps. Understanding Cloud ecosystems – what is SaaS/PaaS, popular APIs.

Unit-IV [18L]

Cloud Architectures and Storage Systems Service Oriented architecture, SOAP and REST architecture, Utility Computing, Web2.0, Cluster computing and Grid Computing, Cloud Storage Concepts Distributed File Systems (HDFS, Ceph FS); Cloud Databases (HBase,

MongoDB, Cassandra, DynamoDB) ; Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph)

Unit-V [12L]

Deployment of Massive Datasets over cloud: Distributed Programming for the Cloud; Data-Parallel Analytics with Hadoop, Setting -up Hadoop and Spark Cluster on different cloud tools, MapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark, Graph-Parallel Analytics with GraphLab 2.0 (PowerGraph)

Text Books:

T1. Chuck Lam, Hadoop in Action, Manning Publications, 2010
T2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", 2013

Reference Books:

R1. Big Data and Analytics by Seema Acharya, Subhashini Chellapan
R2. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses by Michael Minelli, Michele Chambers, Ambiga Dhiraj

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Understand** the fundamentals of Cloud Computing	PO1, PO12
CO2	**Evaluating** the concept of Big Data	PO3, PO4, PO12, PSO3
CO3	**Explain** different Big Data Framework	PO5, PO6, PO12, PSO3
CO4	**Explain** different cloud computing storage and architectures	PO5, PO6, PO12 , PSO3
CO5	**Apply** big data application	PO6, PO7, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11652	Introduction to Big Data	1	-	1	1	2	3	1	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11088	Introduction to Financial Risk Analytics	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	10+2 Level Mathematics				
Co-requisites	Good knowledge of Probability and statistics, Linear algebra				

Course Objectives:
The objective of the course is:
1. To understand introductory knowledge of financial risk through mathematical applications and learn the basics of financial analysis in terms mathematics and statistics.
2. To solve and analysis some basic problems in financial risk management and asset management by using their mathematical and statistical concept and skills.

Course Outcomes:
After completion of the course the students will be able to
CO1: Apply the concept of basic calculus and portfolio theory for simple financial problems.
CO2: Utilize the linear regression models and ANOVA in financial modeling.
CO3: Apply various numerical techniques to calculate the risk and bond yield in financial applications.
CO4: Explain the various types of risk, portfolios and related theories, capital asset pricing model.
CO5: Find eigen vectors and eigen values in applications to linear portfolios.

Course Description:
This course will enable students to apply mathematical knowledge into financial domain. They can implement several statistical and numerical techniques as well in the financial problems. Several terminologies in the context of financial models will be made familiar to the students and eventually they will be able to apply techniques from linear algebra to solve problems in financial realm.

Course Content

Unit I **[12L]**
Basic Calculus for Finance: Functions and graphs, inverse function, exponential and natural logarithm function with example in finance, equations and roots, Taylor expansion, monotonic, concave and convex functions, review of partial derivatives: function of two variables, stationary points and constrained optimization, some financial applications.
Analysis of financial returns: Portfolio holdings and portfolio weights, profit and loss: discrete time and continuous time, percentage and log returns, geometric Brownian motion and its applications in finance.

Unit II **[10L]**
Review of probability distributions, univariate normal distribution, bivariate normal mixture distributions and its properties, introduction to linear regression, ANOVA and goodness of fit, autocorrelation and heteroscedasticity, applications of linear regression in finance: testing a theory, analyzing empirical market behavior.

Unit III **[10L]**
Numerical Methods in Finance: Calculation of risk and bond yield using bisection, Newton-Raphson method and gradient methods; interpolation and extrapolation, some applications in finance.

Unit IV **[20L]**

Introduction to portfolio theory, portfolio preference, some standard utility functions, mean–variance criterion, portfolio allocation, portfolio diversification, minimum variance portfolios, the Markowitz problem, efficient frontier, optimal allocation.

Portfolio credit risk, counterparty credit risk, portfolios of derivatives, operational risk, credit risk. theory of asset pricing, capital asset pricing model, testing the CAPM, risk adjusted performance measures, sharpe ratio, making decisions using the sharpe ratio.

Unit V: **[8 L]**

Eigenvectors and eigenvalues and its properties, eigenvalues and eigenvectors of a 2×2 correlation matrix, eigenvalue test for definiteness, applications to linear portfolios.

Reference Books

1. Alexander, C. (2008). Quantitative methods in finance. Wiley.
2. Skoglund, J., & Chen, W. (2015). Financial risk management: Applications in market, credit, asset and liability management and firmwide risk. John Wiley & Sons.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Apply** the concept of basic calculus and portfolio theory for simple financial problems.	PO5, PO6, PO12, PSO2
CO2	**Utilize** the linear regression models and ANOVA in financial modeling.	PO4, PO5, PO6, PO12, PSO2
CO3	**Apply** various numerical techniques to calculate the risk and bond yield in financial applications.	PO4, PO5, PO6, PO12, PSO3
CO4	**Explain** the various types of risk, portfolios and related theories, capital asset pricing model.	PO5, PO12
CO5	**Find** eigen vectors and eigen values in applications to linear portfolios.	PO4, PO5, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11088	Introduction to Financial Risk Analytics	-	-	-	3	3	3	-	-	-	-	-	3	-	2	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11037	Actuarial Statistics	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Basic Probability and Statistics				
Co-requisites	--				

Course Objectives:
To develop the concept of premium and insurance in real life.

Course Outcomes
On completion of this course, the students will be able to
CO1. **Recall** the concept of statistics for insurance models.
CO2. **Define** the concept of premium in various models.
CO3. **Illustrate** the idea of survival distribution and life tables.
CO4. **Apply** the concept of insurance in various real-life models.

Course Description:
In this course students will learn various type of probability distributions in sense of application in different types of insurance. Here, they will learn study of various types of models and life tables for premium calculations and annuities. This course has a special emphasize on life insurance models and their studies.

Course Content

Unit I
Introductory Statistics and Insurance Applications: Discrete, continuous and mixed probability distributions. Insurance applications, sum of random variables. Utility theory: Utility functions, expected utility criterion, types of utility function, insurance and utility theory. **[14L]**

Unit II
Principles of Premium Calculation: Properties of premium principles, examples of premium principles. Individual risk models: models for individual claims, the sum of independent claims, approximations and their applications. **[14L]**

Unit III
Survival Distribution and Life Tables: Uncertainty of age at death, survival function, time until-death for a person, curate future lifetime, force of mortality, life tables with examples, deterministic survivorship group, life table characteristics, assumptions for fractional age, some analytical laws of mortality. **[16L]**

Unit IV
Life Insurance: Models for insurance payable at the moment of death, insurance payable at the end of the year of death and their relationships. Life annuities: continuous life annuities, discrete life annuities, life annuities with periodic payments. Premiums: continuous and discrete premiums. **[16L]**

Reference Books

R1. Dickson, C. M. D. (2005): Insurance Risk And Ruin (International Series On Actuarial Science), Cambridge University Press.
R2. Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A. And Nesbitt, C. J. (1997): Actuarial Mathematics, Society Of Actuaries, Itasca, Illinois, U.S.A.

R3. Daykin, C.D, Pentikainen, T & Pesonen, M. (1994). *Practical Risk Theory for Actuaries*, Chapman & Hall.
R4. Atkinson, M.E. & Dickson, D.C.M. (2000). *An Introduction to Actuarial Studies*, Elgar Publ.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		**Mapped POs and PSOs**
CO1	**Recall** the concept of statistics for insurance models.	PO1, PO2, PO5, PO12, PSO1
CO2	**Define** the concept of premium in various models.	PO1, PO2, PO5, PO12, PSO1
CO3	**Illustrate** the idea of survival distribution and life tables.	PO1, PO2, PO5, PO12, PSO1
CO4	**Apply** the concept of insurance in various real-life models.	PO1, PO2, PO5, PO12, PSO1

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11037	Actuarial Statistics	3	3	-	-	3	-	-	-	-	-	-	3	3	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE11653	Introduction to Deep Learning	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	3	1	0	4
Pre-requisite/Exposure	Discrete Mathematics, Calculus, Machine Learning				
Co-requisite	NIL				

Course Objectives:

1. To enable students to analyze different components of a neural network
2. To provide the fundamentals of building problem specific neural networks
3. To enhance the skill of students to manipulate the parameters of deep learning models
4. To allow students to identify challenging areas where deep learning solutions can be implemented

Course Outcomes:

On the completion of this course the student will be able to

CO1. Understand the fundamental building blocks neural networks
CO2. Analyze the different parameters that controls the performance of neural networks
CO3. Explain various types of deep learning techniques
CO4. Compare several key deep learning models for different types of problems
CO5. Develop deep learning models by using state-of-the-art tools.

Course Description:

This course requires minimal knowledge in discrete mathematics, differential calculus and basic machine learning. The course starts from single node neurons to multi-layered neural networks. While discussing all relevant challenges in this field, deep learning techniques are introduced. Most advanced features of deep learning techniques have been discussed; A broad array of deep learning models have been analysed to aid in problem specific model design. Finally, with the help of modern deep learning tools such as Tensorflow, Keras and Pytorch, students are prepared to tackle challenging problems in the field of computer vision, natural language processing, sequence analysis and so on.

Course Content:

Unit-I [08L]

Introduction:

Evolution of machine learning techniques, history of neural learning systems, linear and logistic regression, decision boundaries.

Neural Network Architecture:

Biological vs artificial neuron, perceptron, XOR problem, stochastic gradient descent, weights and biases, activation functions, non-linearity, multi-layered perceptron

Unit-II [08L]

Controlling the Neural Network:

Restricted Boltzmann machines, back-propagation, learning rate, momentum, adaptive learning rates, regularization, hyper-parameter management, ensemble techniques.

Neural Network Models:

Hopfield neural networks, recurrent neural networks, Self-organizing feature maps, auto-encoders.

Unit-III [14L]

Deep Learning Techniques:

Vanishing gradients, deep belief networks, long short-term memory, representation learning, convolutional neural networks, Subsampling, rectified-linear units, deep convolutional auto-encoders, layer-wise training, auxiliary classifiers, residual connections, adversarial learning.

Unit-IV [18L]

Deep Learning Models:

Classification: LeNet-5, AlexNet, VGG-Net, GoogLeNet, ResNet, DenseNet, MobileNet.
Detection: R-CNN, YOLO
Segmentation: Seg-Net, U-Net, SegFast
Sequential Learning: LSTM, GRU
Generative Learning: Variational auto-encoder, GAN, Conditional GAN

Unit-V [12L]

Deep Learning Tools:

PyTorch: Installation, Tensors, autograd, modules, dataset and dataloader, Training and Testing
TensorFlow: Installation, Loading dataset, Model, Training, Testing

Text Books:

T1. Neural Networks and Learning Machines - Simon Haykin – Pearson Prentice Hall
T2. Deep Learning – Ian Goodfellow, Yoshua Bengio, Aaron Courville – MIT Press

Reference Books:

R1. Deep Learning with PyTorch: A 60 Minute Blitz
R2. Tensor Flow 2 quickstart for beginners

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Understand** the fundamental building blocks neural networks	PO1, PO12
CO2	**Analyze** the different parameters that controls the performance of neural networks	PO2, PO3, PO12, PSO3
CO3	**Explain** various types of deep learning techniques	PO3, PO4, PO12, PSO3

CO4	**Compare** several key deep learning models for different types of problems	PO4, PO5, PO12, PSO3
CO5	**Develop** deep learning models by using state-of-the-art tools.	PO4, PO5, PO6, PO12, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE11653	Introduction to Deep Learning	1	1	2	3	2	1	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

CSE12654	Introduction to Deep Learning Practical	L	T	P	C
Version 1.0	Contact Hours – 60 Hours	0	0	2	2
Pre-requisite/Exposure	Discrete Mathematics, Calculus, Machine Learning				
Co-requisite					

Course Objectives:

1. To enable students to analyze different components of a neural network
2. To provide the fundamentals of building problem specific neural networks
3. To enhance the skill of students to manipulate the parameters of deep learning models
4. To allow students to identify challenging areas where deep learning solutions can be implemented

Course Outcomes:

On the completion of this course the student will be able to

CO1. **Understand** the fundamental building blocks neural networks
CO2. **Analyze** the different parameters that controls the performance of neural networks
CO3. **Explain** various types of deep learning techniques
CO4. **Compare** several key deep learning models for different types of problems
CO5. **Develop** deep learning models by using state-of-the-art tools.

Course Description:

This course requires minimal knowledge in discrete mathematics, differential calculus and basic machine learning. The course starts from single node neurons to multi-layered neural networks. While discussing all relevant challenges in this field, deep learning techniques are introduced. Most advanced features of deep learning techniques have been discussed; A broad array of deep learning models have been analysed to aid in problem specific model design. Finally, with the help of modern deep learning tools such as Tensorflow, Keras and Pytorch, students are prepared to tackle challenging problems in the field of computer vision, natural language processing, sequence analysis and so on.

List of Experiments:

1) Write a program to implement linear and logistic regression
2) Write a program to implement a perceptron
3) Plot the local inference field and decision boundaries of a perceptron
4) Implement stochastic gradient descent algorithm
5) Implement a multi-layered perceptron
6) Implement back-propagation algorithm
7) Implement filter based approaches for edge detection
8) Write a program to implement convolution operation and rectified linear units.
9) Write a program to implement max-pooling and average pooling operation
10) Write a program in python to implement various loss functions
11) Write a program using Pytorch to design LeNet5 architecture and classify the MNIST Dataset
12) Write a program using Pytorch to design U-Net architecture and segment the CamVid Dataset
13) Write a program using Pytorch to generate fake dataset using GAN
14) Implement ResNet using TensorFlow and Keras
15) Implement an LSTM using TensorFlow and Keras

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination
Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)
Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Understand** the fundamental building blocks neural networks	PO1, PO12
CO2	**Analyze** the different parameters that controls the performance of neural networks	PO2, PO3, PO12, PSO3
CO3	**Explain** various types of deep learning techniques	PO3, PO4, PO12, PSO3
CO4	**Compare** several key deep learning models for different types of problems	PO4, PO5, PO12, PSO3
CO5	**Develop** deep learning models by using state-of-the-art tools.	PO4, PO5, PO6, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CSE12654	Introduction to Deep Learning Practical	1	1	2	3	2	1	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11030	Data Manipulation and Data Cleaning in R	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

- Understand the importance of data manipulation and cleaning for good data analytic practices.
- Understand how to clean, manipulate, select, and transform data both under standardized and conditional conditions.

Course Outcomes

On completion of this course, the students will be able to

CO1. **Explain** basics of R language
CO2. **Apply** several packages in R to manipulate data
CO3. **Make use of** different techniques and packages for data cleaning
CO4. **Apply** data manipulation techniques for real-life problems

Course Description:

In this course students will learn various type of probability distributions in sense of application in different types of insurance. Here, they will learn study of various types of models and life tables for premium calculations and annuities. This course has a special emphasize on life insurance models and their studies.

Course Content:

Unit I

Introduction to R Data Types and Basic Operations, package installation, R as an enterprise solution, writing commands in R, R data types and basic operations, factor and its type: data frame, arrays, matrix, list, basic data manipulation, acquiring data, vector and matrix, factor manipulation, advanced manipulation. **[12L]**

Unit II

Data manipulation using Plyr and dplyr, filtering and slicing row, arranging row, column wise descriptive statistics, group-wise operations, Reshaping datasets, layouts of datasets, melting data, casting molten data, R and databases, relational databases in R. **[14L]**

Unit III

Data cleaning, the Statistical Value Chain, Raw Data, Input Data, Valid Data, Statistics, Output, The Formula-Data Interface, Selecting Rows and Columns, Boolean Operators, Selection with Indices, Data Frame Manipulation, Special Values, Missing Values, Getting Data into and out of R, File Paths in R, using functions, writing functions. **[16L]**

Unit IV

Cleaning Text Data, Basic Regular Expressions, Approximate Text Matching, Data Validation, Localizing Errors in Data Records, Rule Set Maintenance and Simplification, Methods Based on Models for Domain Knowledge, Correction with Data Modifying Rules, Imputation and Adjustment, A Small Data-Cleaning System, Automated Data Cleaning. **[18L]**

Reference Books

R1. Van der Loo, M., & de Jonge, E. (2018). Statistical data cleaning with applications in R. John Wiley & Sons.

R2. Spector, P. (2008). Data manipulation with R. Springer Science & Business Media.

R3. Abedin, J. & Das, K. K. Data Manipulation with R. Packt Publishing Ltd.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Explain** basics of R language	PO1, PO2, PO12, PSO3
CO2	**Apply** several packages in R to manipulate data	PO1, PO2, PO6, PO12, PSO3
CO3	**Make use of** different techniques and packages for data cleaning	PO1, PO2, PO6, PO12, PSO3
CO4	**Apply** data manipulation techniques for real-life problems	PO1, PO2, PO3, PO12, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11030	Data Manipulation and Data Cleaning in R	3	3	1	-	-	3	-	-	-	-	-	3	-	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS12031	Data Manipulation and Data Cleaning in R Practical	L	T	P	C
Version 1.0	Contact Hours - 45	0	0	3	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives:

- Understand the importance of data manipulation and cleaning for good data analytic practices.
- Understand how to clean, manipulate, select, and transform data both under standardized and conditional conditions.

Course Outcomes

On completion of this course, the students will be able to

CO1. **Explain** basics of R language
CO2. **Apply** several packages in R to manipulate data
CO3. **Make use of** different techniques and packages for data cleaning
CO4. **Apply** data manipulation techniques for real-life problems

Course Description:

It is said approximately 80-90% of a statistician, data scientist or analysts time is spent cleaning, manipulating, or exploring presented data. During this interactive practical, we will dive into both the reasons for these processes, as well as how to undertake basic cleaning, manipulation, selection and transformations of data, during both standardized and conditional situations. This session is aimed at complete beginners, or those wanting to refresh their data handling skills in R.

Course Content:

List of Practical

1. Introduction to R
2. Data Types and Basic Operations
3. Installing R packages
4. Writing R commands
5. Forming data frames, arrays, matrix, list
6. Basic data manipulation commands
7. Advanced data manipulation commands
8. Arranging row and column and column wise descriptive statistics
9. melting data, casting molten data
10. Selecting rows and columns.
11. Data Frame Manipulation
12. Importing and exporting data
13. Writing functions in R
14. Data cleaning
15. Text cleaning
16. Automated data cleaning

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Explain** basics of R language	PO1, PO6, PO12, PSO3
CO2	**Apply** several packages in R to manipulate data	PO1, PO6, PO12, PSO1, PSO3
CO3	**Make use of** different techniques and packages for data cleaning	PO1, PO6, PO12, PSO1, PSO3
CO4	**Apply** data manipulation techniques for real-life problems	PO1, PO3, PO6, PSO1, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS12031	Data Manipulation and Data Cleaning in R Practical	3	-	1	-	-	3	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11089	Survey Sampling	L	T	P	C
Version 1.0	**Contact Hours - 60**	3	1	0	4
Pre-requisites/Exposure	Basic knowledge of Statistical Inference				
Co-requisites	--				

Course Objectives:
To provide students with an exposure to the applications different Survey sampling in real-life situations.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Explain** the introductory concepts related to Survey Sampling.
CO2. **Build** knowledge about Simple Random Sampling (SRS) and Stratified Random Sampling (STRS) and their applications.
CO3. **Make use of** the knowledge of Systematic Sampling and Ratio & Regression methods of estimation in real-life scenarios.
CO4. **Apply** the concepts of Cluster and Two-stage Sampling to different situations.

Course Description:
Initially, students will learn about several fundamentals of sampling. They will become acquainted with different types of sampling which will help them to grab an idea regarding various sampling schemes in real life problems. They will be able to estimate certain population parameters with the help of these methods.

Course Content:

Unit I: Introduction to Survey Sampling [10L]
Concepts of Population and Sample, Sampling and its need, Types of Population and Sampling, Basic principles of Survey Sampling, Complete Enumeration versus Sampling, Stages in large-scale Survey Sampling, Sampling and Non-sampling Errors, Technique of Random Sampling – use of a Random Sampling Number Series.

Unit II: Simple Random Sampling and Stratified Random Sampling [25L]
Simple Random Sampling: With and Without Replacement, definition and procedure of selecting a Sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination. Applications. Stratified Random Sampling: Technique, estimates of population mean and total, variances of these estimates, Proportional and Optimum allocations and their comparison with SRS. Practical difficulties in allocation, estimation of gain in precision. Applications.

Unit III: Systematic Sampling and Ratio & Regression Methods of Estimation [15L]
Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N = n \times k$). Comparison of Systematic Sampling with SRS and Stratified Sampling in the presence of linear trend and corrections. Introduction to Ratio and Regression methods of estimation, first approximation to the population mean and total (for SRS of large size), MSE of these estimates and estimates of these variances, MSE in terms of correlation coefficient for Regression method of estimation and their comparison with SRS. Hartley Ross Estimator.

Unit IV: Cluster Sampling and Two-stage Sampling [10L]

Cluster sampling (equal clusters only), estimation of population mean and its variance, comparison (with and without randomly formed clusters). Concept of sub sampling. Two-stage Sampling, Estimation of population mean and variance of the estimate. Comparison between Two-stage, Cluster and Uni-stage Sampling.

Text Books

T1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn., The World Press, Kolkata

T2. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice Hall

Reference Books

R1. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta

R2. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern

R3. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Mid-term Examination	Continuous Assessment	End Term Examination
Weightage (%)	**20**	**30**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Explain** the introductory concepts related to Survey Sampling.	PO1, PO12, PSO2
CO2	**Build** knowledge about Simple Random Sampling (SRS) and Stratified Random Sampling (STRS) and their applications.	PO6, PO7, PO8, PO12, PSO3
CO3	**Make use of** the knowledge of Systematic Sampling and Ratio & Regression methods of estimation in real-life scenarios.	PO6, PO7, PO8, PO12, PSO3
CO4	**Apply** the concepts of Cluster and Two-stage Sampling to different situations.	PO6, PO7, PO8, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS11089	Survey Sampling	2	-	-	-	-	3	3	3	-	-	-	3	-	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS11090	Survey Sampling Practical	L	T	P	C
Version 1.0	**Contact Hours - 45**	0	0	3	2
Pre-requisites/Exposure	Basic knowledge of Statistical Inference and Survey Sampling				
Co-requisites	Use of scientific calculators and/or Microsoft Excel				

Course Objectives:
To provide students the hands-on experience of different statistical methods relating to Survey Sampling along with their real-life applications.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Build** knowledge about solving problems of Simple Random Sampling (SRS).
CO2. **Build** knowledge about solving problems of Stratified Random Sampling (STRS).
CO3. **Make use of** the knowledge about solving problems of Systematic Sampling and Ratio & Regression methods of estimation.
CO4. **Apply** the procedures of solving problems of Cluster and Two-stage Sampling.

Course Description:
Initially, students will learn about several fundamentals of sampling along with their applications. They will become acquainted with different types of sampling which will help them to grab an idea regarding various sampling schemes in real life problems. They can handle several problems on different types of sampling techniques with ace.

Course Content:

List of experiments (to be executed using Scientific Calculators and/or MS Excel)

Sl. No.	Name of the Experiments
1	To select a SRS With and Without Replacement.
2	For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3	For SRSWOR, estimate mean, standard error, the sample size.
4	Stratified Random Sampling: allocation of sample to strata by proportional and Neyman's methods. Compare the efficiencies of the two methods relative to SRS.
5	Estimation of gain in precision in Stratified Random Sampling.
6	Comparison of Systematic Sampling with Stratified Random Sampling and SRS in the presence of a linear trend.
7	Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares.
8	Compare the efficiencies of Ratio and Regression estimators relative to SRS.
9	Cluster Sampling: estimation of mean or total, variance of the estimate.
10	Two-stage Sampling.

Text Books

T1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edn., The World Press, Kolkata
T2. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice Hall

Reference Books

R1. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta

R2. Cochran W.G. (1984): Sampling Techniques (3rd Ed.), Wiley Eastern

R3. Gupta S. C. & Kapoor V. K. (1975): Fundamentals of Applied Statistics: A Modern Approach. S. Chand & Company

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Build** knowledge about solving problems of Simple Random Sampling (SRS).	PO1, PO12, PSO2
CO2	**Build** knowledge about solving problems of Stratified Random Sampling (STRS).	PO6, PO7, PO8, PO12, PSO3
CO3	**Make use of** the knowledge about solving problems of Systematic Sampling and Ratio & Regression methods of estimation.	PO6, PO7, PO8, PO12, PSO3
CO4	**Apply** the procedures of solving problems of Cluster and Two-stage Sampling.	PO6, PO7, PO8, PO12, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
SDS11090	Survey Sampling Practical	2	-	-	-	-	3	3	3	-	-	-	3	-	2	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH11017	Introduction to Numerical Analysis	L	T	P	C
Version 1.0	Contact Hours - 60	3	1	0	4
Pre-requisites/Exposure	Basic Mathematics				
Co-requisites	--				

Course Objectives:
To introduce the numerical approaches for solving various mathematical problems.

Course Outcomes
On completion of this course, the students will be able to
CO1. Find the errors in numerical methods, and numerical solutions of nonlinear equations with single variable.
CO2. Illustrate the solution procedure of system of linear algebraic equations.
CO3. Develop the basic knowledge of finite differences, interpolation and divided differences.
CO4. Demonstrate the concept of numerical differentiation and integration.
CO5. Solve the ordinary differential equations by several numerical methods.

Course Description:
Numerical analysis is the subject of study to find the numerical solutions of mathematical problems by computational methods. Numerical techniques are effective tools for providing solutions to mathematical problems which are not solved by analytical methods. It studies the numerical solutions to the problems involving nonlinear equations, system of linear algebraic equations, interpolation and approximation, empirical laws for curve fitting, differences, integrals, ordinary and partial differential equations, finite differences, etc. Numerical methods are normally being used to find the solution to a problem whose analytical solution is difficult to achieve, thus it is felt that a study in applied sciences and engineering is essential and found wide applications in all areas of science, technology and economics.

Course Content:

Unit-I **[14 L]**
Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation errors, Propagation of errors, Roots of algebraic and transcendental equations: Bisection method, Regular-Falsi method, Secant method, Fixed point iteration method, Newton-Raphson method, Rate of convergence of these methods, Numerical solution to system of non-linear equation by Newton-Raphson
method.

Unit-II **[14 L]**
System of linear algebraic equations: Gaussian Elimination method, Pivot element, Gauss-Jordan method, LU-Decomposition methods and their applications, Ill-conditioned system and its solution, Gauss-Jacobi method, Gauss-Seidel method and their convergence analyses.

Unit-III **[14 L]**
Interpolation: Finite difference operators and their relations, Synthetic division, Newton's forward and backward difference formulae, Numerical differentiation and its applications.

Interpolation with unequal intervals: Lagrange's interpolation formula, Divided difference, Newton's divided difference interpolation formula.

Unit-IV **[18 L]**

Numerical integration: Newton-Cotes quadrature formula, Trapezoidal rule, Simpson's rules, Weddle's rule, Error analysis, Guassian-Quadrature formulae (2, 3-point rules).

Numerical solutions of ODE: Taylor's method, Picard's method, Euler's method, Modified Euler's method, Second and fourth order Runge-Kutta methods.

References:

1. T. Veerarajan, T. Ramachandran, Numerical Methods with Programs in C, Tata McGraw-Hill Publications.
2. S. Dey, S. Gupta, Numerical Methods, McGraw Hill Education.
3. S. S. Sastry, Introductory Methods of Numerical Analysis. PHI Learning Pvt. Ltd, 2012.
4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition, 2007.
5. B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C & C++, Khanna Publications, 2013.
6. S. S. Ray, Numerical Analysis with Algorithms and Programming. Chapman and Hall/CRC, 2018.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Mid term	Class Assessment	End Term
Weightage (%)	20	30	50

Relationship between the Course Outcomes (COs) with Program Outcomes (POs)

Mapping between COs, POs		
Course Outcomes (COs)		Mapped POs and PSOs
CO1	**Find** the errors in numerical methods, and numerical solutions of nonlinear equations with single variable.	PO1, PO2, PO5, PO12, PSO1, PSO3
CO2	**Illustrate** the solution procedure of system of linear algebraic equations.	PO1, PO3, PO5, PO12, PSO1, PSO3
CO3	**Develop** the basic knowledge of finite differences, interpolation and divided differences.	PO1, PO2, PO3, PO12, PSO3
CO4	**Demonstrate** the concept of numerical integration and differentiation.	PO1, PO3, PO5
CO5	**Solve** the ordinary differential equations by several numerical methods.	PO1, PO2, PO12, PSO1, PSO3

		Academic Excellence	Contextualized Understanding	Design/development of solutions	Conduct investigations of complex problems	Quantitative Aspects	Modernization and Tools Usage	Societal Implication	Environment and Sustainability	Ethics	Individual and Team Work	Communication	Life Long Learning	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH 11017	Introduction to Numerical Analysis	3	3	3	-	3	-	-	-	-	-	-	3	3	-	3

1=weakly mapped
2= moderately mapped
3=strongly mapped

MTH12019	Introduction to Numerical Analysis Lab	L	T	P	C
Version 1.0	Contact Hours - 45	0	0	3	2
Pre-requisites/Exposure	Theory of Numerical Analysis				
Co-requisites	C/MATLAB- Programming				
Co-requisites	--				

Course Objectives:
To develop the student's skills in numerical approaches by using the coding-based computer facilities.

Course Outcomes:
On completion of this course, the students will be able to

CO1. **Write** the programming code for finding the roots of non-linear equations with single variable.
CO2. **Write** the programming code for finding the roots of system of linear algebraic equations.
CO3. **Build** the programming code for finding the interpolate value of a given data set values.
CO4. **Develop** the programming code for finding the solution of a given integral.
CO5. **Discover** the programming code for finding the solution of an ordinary differential equation.

Course Description:
Numerical computations play a crucial role in solving simple to complex problems in science and engineering. Growing power and efficiency of the modern computers has made the numerical computations more sophisticated, accurate and powerful. Practical knowledge of numerical computation techniques is very essential for modern science and engineering. This lab course is designed for under graduate students to provide them comprehensive knowledge and practical experience of solving various mathematical problems using suitable numerical techniques. In this course students will learn algorithms and write computer programs for the numerical techniques towards solving problems. The course includes techniques for solving non-linear equations and system of linear equations, computing interpolations and integrations of functions, and solving ordinary differential equations. All the lectures will be devoted on discussions of basic theories and advanced topics, focusing on practical implementation of knowledge.

Course Content:

Write and execute C/MATLAB-code for the following programs:

Sl. No.	Name of the experiment
1.	The root of non-linear equation using Bisection method.
2.	The root of non-linear equation using false position method.
3.	The root of non-linear equation using Newton-Raphson method.
4.	Solve the system of equation using Gauss-Elimination Method.
5.	Solve the system of equation using Gauss-Seidel iteration method.
6.	Interpolate values using Newton's forward interpolation.
7.	Interpolate values using Newton's backward interpolation
8.	Interpolate values using Lagrange's method.
9.	Evaluate the integral using Trapezoidal rule.
10.	Evaluate the integral using Simpson's rule.

11. Evaluate the integral using Weddle‘s rule.
12. Evaluate the differential equation by Euler’s method.
13. Evaluate the differential equation by Runge-Kutta methods.

Text Books:

T1. B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C & C++, Khanna Publications, 2013.
T2. S. S. Ray, Numerical Analysis with Algorithms and Programming. Chapman and Hall/CRC, 2018.

Reference Books:

R1. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edn., McGraw Hill, 1980.
R2. T. Veerarajan, T. Ramachandran, Numerical Methods with Programs in C, Tata McGraw-Hill Publications.
R3. Shah, N.H., Numerical Methods with C++ programming. PHI Learning Pvt. Ltd, 2008.
R4. W.Y. Yang, W. Cao, J. Kim, K.W. Park, H. H. Park, J. Joung, J. S. Ro, H. L. Lee, C. H. Hong and T. Im, Applied numerical methods using MATLAB. John Wiley & Sons, 2020.

Modes of Evaluation: Assignment/Quiz/Project/Presentation/Written Examination

Examination Scheme:

Components	Continuous Assessment	End Term Examination
Weightage (%)	**50**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs
CO1	**Find** errors in numerical computation real roots of algebraic and transcendental equations **using** Bisection method, Regula-Falsi method and Newton Raphson method.	PO5, PO6, PO12, PSO1
CO2	**Solve** system of linear equations using direct method and iteration method.	PO5, PO6, PO12, PSO1
CO3	**Illustrate** several methods of finite differences to obtain interpolating and extrapolating values from a set of data using.	PO5, PO6, PO12, PSO1
CO4	**Classify** Trapezoidal rule and Simpson’s $1/3^{rd}$ rule to obtain the value of an integral with finite limit.	PO5, PO6, PO12, PSO1

CO5	**Utilize** Euler method, Runge-Kutta to obtain the solution to ordinary differential equations with initial conditions.	PO5, PO6, PO12, PSO1

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a	Be familiar with a variety of examples where	Enhance theoretical rigor with technical skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MTH 12019	Introduction to Numerical Analysis Lab	-	-	-	-	3	3	-	-	-	-	-	3	3	-	-

1=weakly mapped
2= moderately mapped
3=strongly mapped

SDS15091	Project Work	L	T	P	C
Version 1.0		-	-	-	8
Pre-requisites/Exposure	All Statistics & Data Analytics subjects				
Co-requisites	--				

Course Objectives:

1. To address the real-world problems and find the required solution.
2. To fabricate and implement the mini project intended solution for project-based learning
3. To improve the team building, communication and management skills of the students

Course Outcomes

On completion of this course, the students will be able to

CO1. Recall the requirements for the real world problems.
CO2. Demonstrate the project successfully by visualizing, analysing, testing and interpreting.
CO3. Construct data analytical skills.
CO4. Examine the findings of the study conducted in the preferred domain

Course Description:

The role of project dissertation in Statistics and Data Science is very important. Project helps a student to explore and strengthen the understanding of fundamentals through practical application of theoretical concepts. Statistics is the basis of many areas including data science, agriculture, finance, industry. Everything around us needs statistical analysis for acceptance. Project allows a student to apply Statistical theory in practical purpose to draw some valid conclusions. It acts like a beginner's guide to do larger projects later in their career. It not just affects the grades of the program but also matter a lot for good CV/Resume. So before choosing the minor and major project, you should explore the options and pick the correct domain where the opportunities are immense.

Modes of Examination: Assignment/Quiz/Project/Presentation/Written Exam

Examination Scheme:

Components	Presentation	Project report	Viva
Weightage (%)	**25**	**25**	**50**

Relationship between the Course Outcomes (COs) with Program Outcomes (POs) and Program Specific Outcomes (PSOs)

Mapping between COs, POs and PSOs

Course Outcomes (COs)		Mapped POs and PSOs
CO-1	Recall the requirements for the real-world problems.	PO1, PO10, PSO3
CO-2	Demonstrate the project successfully by visualizing, analysing, testing and interpreting.	PO3, PO9, PO10, PSO1
CO-3	Construct data analytical skills.	PO3, PO9, PO10, PSO3
CO-4	Examine the findings of the study conducted in the preferred domain	PO3, PO4, PO9, PSO3

		Academic Excellence	**Contextualized Understanding**	**Design/development of solutions**	**Conduct investigations of complex problems**	**Quantitative Aspects**	**Modernization and Tools Usage**	**Societal Implication**	**Environment and Sustainability**	**Ethics**	**Individual and Team Work**	**Communication**	**Life Long Learning**	Have the versatility to work effectively in a broad range of analytic,	Be familiar with a variety of examples where mathematics or statistics	Enhance theoretical rigor with technical skills which prepare students to
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SDS15091	Project Work	2	-	3	1	-	-	-	-	3	3	-	-	1	-	3

1=weakly mapped

2= moderately mapped

3=strongly mapped

ADAMAS UNIVERSITY
SCHOOL OF BASIC AND APPLIED SCIENCES
DEPARTMENT OF MATHEMATICS
CO – PO MAPPING

Name of the Programme: B.Sc. (Hons) Statistics and Data Analytics

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
MTH11033	CALCULUS	3	1	-	-	-	2	-	-	-	-	-	3
SDS11072	PROBABILITY THEORY	3	3	3	3	3	-	-	-	-	-	-	3
SDS11001	DESCRIPTIVE STATISTICS	3	3	3	3	3	-	-	3	-	-	-	-
SDS12002	DESCRIPTIVE STATISTICS PRACTICAL	3	-	3	-	3	3	2	1	-	-	-	-
ENG11057	ENGLISH LANGUAGE AND LITERATURE	-	-	-	-	-	-	-	-	2	3	1	3
CSE11655	ELECTIVE PROGRAMMING LANGUAGE I	2	-	2	-	-	3	-	-	-	-	-	3
CSE12656	ELECTIVE PROGRAMMING LANGUAGE I LAB	3	3	3	-	3	3	-	-	-	-	-	3
CHM11151	ELECTIVE CHEMISTRY I	3	3	3	-	2	-	-	-	-	-	-	3
CHM12152	ELECTIVE CHEMISTRY I LAB	3	3	3	-	2	-	-	-	-	-	-	3
DGS11001	DESIGN THINKING	3	2	-	-	2	-	-	-	-	-	2	-
SDS11073	PROBABILITY DISTRIBUTIONS	3	3	3	2	3	3	-	-	-	-	-	3
SDS12074	PROBABILITY DISTRIBUTIONS PRACTICAL	3	3	3	3	3	-	-	-	-	-	-	3
MTH11034	REAL ANALYSIS	3	-	-	-	-	-	-	-	-	-	-	-
MTH11080	LINEAR ALGEBRA	3	3	-	-	-	-	-	-	-	-	-	3
EVS11112	ENVIRONMENTAL SCIENCE	1	1	1	-	-	3	3	2	-	-	-	1
CSE11657	ELECTIVE PROGRAMMING LANGUAGE II	3	1	3	3	3	-	-	-	-	-	-	3
CSE12658	ELECTIVE PROGRAMMING LANGUAGE II LAB	3	1	3	3	3	-	-	-	-	-	-	3
CHM11153	ELECTIVE CHEMISTRY II	3	3	3	-	2	-	-	-	-	-	-	3
CHM12154	ELECTIVE CHEMISTRY LAB II	3	3	3	-	2	-	-	-	-	-	-	3
EIC11001	VENTURE IDEATION	-	-	-	-	-	3	-	3	-	-	3	-
SDS11075	SAMPLING THEORY	3	-	3	-	3	3	-	-	-	-	-	3

SDS11076	STATISTICAL INFERENCE	3	-	3	3	-	3	-	-	-	-	-	3
SDS12077	STATISTICAL INFERENCE PRACTICAL	-	-	3	3	-	3	-	-	-	-	-	3
SDS11078	INDEX NUMBERS AND TIME SERIES ANALYSIS	2	-	3	-	-	3	3	-	-	-	-	3
SDS12079	INDEX NUMBERS AND TIME SERIES ANALYSIS PRACTICAL	2	-	3	-		3	3					3
SDS13080	R-PROGRAMMING	3				3	3						3
ECO11001	MICROECONOMICS	2	2	1	1	-	-	3	-	3	3	-	3
PHY11015	ELECTIVE PHYSICS I	3	-	2	-	-	2	2	2	3	3	1	3
PHY12016	ELECTIVE PHYSICS LAB I	3	-	2	-	-	2	2	2	3	3	1	3
SOC14100	COMMUNITY SERVICE							3		3	3		3
IDP14001	INTER-DISCIPLINARY PROJECT	3		2					3	3			
SDS11005	LINEAR MODELS	3			3		3		3				2
SDS12006	LINEAR MODELS PRACTICAL	3		2	3	2	3						3
CSE11646	DATABASE MANAGEMENT SYSTEM	2	2	2	2	2	2						3
CSE12647	DATABASE MANAGEMENT SYSTEM PRACTICAL	2	2	2	2	2	2						3
MTH11035	DISCRETE MATHEMATICS	3			3								3
SDS13081	PYTHON FOR DATA SCIENCE	2	1	3	1	3	2						3
ECO11031	MACROECONOMICS	2	2	1	1			3		3	3		3
PHY11024	ELECTIVE PHYSICS II	3	2	1	1								
PHY12025	ELECTIVE PHYSICS II LAB									3	2	1	1
PSG11021	HUMAN VALUES AND PROFESSIONAL ETHICS							2		3			3
MTH11036	OPERATIONS RESEARCH	2	2	3	3	3	1	-	-	-	-	-	3
SDS11020	DESIGN OF EXPERIMENTS AND MULTIVARIATE ANALYSIS	3			3		3		3	-	-	-	3
SDS12021	DESIGN OF EXPERIMENTS AND MULTIVARIATE ANALYSIS PRACTICAL	3			3		3		2				3
CSE11650	INTRODUCTION TO MACHINE LEARNING	3	2	3	3		1						3
CSE12651	INTRODUCTION TO MACHINE LEARNING PRACTICAL	3			3		3						3
SDS11015	EXPLORATORY DATA ANALYSIS AND VISUALIZATION	3	3	3		2							3
SDS12083	EXPLORATORY DATA ANALYSIS AND VISUALIZATION PRACTICAL	3		3	3		3						3
ECO11504	ECONOMETRICS	2		2			3	-	3		3		3

SDS11086	STATISTICAL QUALITY CONTROL	2		2	2	3	3	-	-				3
MTH11038	SOFT COMPUTING				3		3						3
CSE11659	DESIGN AND ANALYSIS OF ALGORITHM			3		3							3
SDS14039	SUMMER INTERNSHIP	2		2			3			3	2		
SDS11084	INTRODUCTION TO DATA MINING	3	3	3	3								3
SDS12085	INTRODUCTION TO DATA MINING PRACTICAL	3				3	3						3
MTH11081	INTRODUCTION TO DECISION SCIENCE	3	3	3	2	3	2						3
SDS11087	DEMOGRAPHY AND SURVIVAL ANALYSIS				2	3	3		3				3
CSE11652	INTRODUCTION TO BIG DATA	1		1	1	2	3	1					3
SDS11088	INTRODUCTION TO FINANCIAL RISK ANALYTICS				3	3	3						3
SDS11037	ACTUARIAL STATISTICS	3	3			3							3
CSE11653	INTRODUCTION TO DEEP LEARNING	1	1	2	3	2	1						3
CSE12654	INTRODUCTION TO DEEP LEARNING PRACTICAL	1	1	2	3	2	1						3
SDS11030	DATA MANIPULATION AND DATA CLEANING IN R	3	3	1			3						3
SDS12031	DATA MANIPULATION AND DATA CLEANING IN R PRACTICAL	3		1			3						3
SDS11089	SURVEY SAMPLING	2					3	3	3				3
SDS12090	SURVEY SAMPLING PRACTICAL	2					3	3	3				3
MTH11017	INTRODUCTION TO NUMERICAL ANALYSIS	3	3	3		3							3
MTH12019	INTRODUCTION TO NUMERICAL ANALYSIS LAB					3	3						3
SDS15091	PROJECT WORK	2		3	1					3	3		
Average of CO-PO Mapping		2.6	2.3	2.4	2.4	2.6	2.6	2.5	2.6	2.9	2.8	1.5	2.9