Adamas University
School of Basic and Applied Sciences
Department of Mathematics

Syllabus of

M.Sc. Tech (Statistics and Data Science)

Programme Code: MTH4202
Duration: 2 Years Full Time
Academic Year: 2024-25

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 of the University

- Improve employability through futuristic curriculum and progressive pedagogy with cutting-edge technology
- Foster outcomes based education system for continuous improvement in education, research and all allied activities
- Instill the notion of lifelong learning through culture of research and innovation
- Collaborate with industries, research centers and professional bodies to stay relevant and up-to-date
- Inculcate ethical principles and develop understanding of environmental and social realities

Core Values

- Respect
- Positivity
- Commitment
- Accountability
- Innovation

Vision of the School

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

Mission of the School

- Develop solutions for the challenges in sciences through value-based science education.
- Conduct research leading to innovation in sciences.
- Nurture students into scientifically competent professionals in the usage of modern tools.
- Foster in students, a spirit of inquiry and collaboration to make them ready for careers in teaching, research and corporate world.

Vision of the Department

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

Mission of the Department

- Deliver graduates with considerable Mathematical and Statistical skills along with real-world problem-solving ability.
- Create a framework to nurture students through outcome-based education towards building a strong foundation in mathematical sciences for academia and industry.
- Conduct fundamental and cutting-edge collaborative research on mathematical and interdisciplinary fields.
- Contribute towards development of mathematical foundation in pan-university level.

Programme Educational Objectives (PEO) of M.Sc. Tech (Statistics and Data Science):

PEO 01: Graduates will equip with knowledge and understanding of statistical theory and its applications within data science.
PEO 02: Graduate will equip with the ability to implication of application in the statistical and data science field.
PEO 03: Graduates of this programme will establish as effective professionals by learning technical skills in Data Science field.
PEO 04: Students will gain proficiency in using statistical software R/Python for data science.

Programme Outcomes (POs) and Programme Specific Outcomes (PSOs) of M.Sc. Tech (Statistics and Data Science)

Students of the postgraduate programme, at the time of graduation will be able to have:

PO1	**Academic Excellence**	Understand the basic concepts, fundamental principles and the scientific theories related to Statistics and Data Science.
PO2	**Contextualized Understanding**	Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematics and Statistics.
PO3	**Research and Analysis**	Students will be acquainted with various research opportunities in the area of Statistics and Data Science both at home and abroad.
PO4	**Problem Solving Skills**	Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.
PO5	**Modernization and Tools Usage**	Acquire the skills in handling statistical tools and programming towards problem solving and solution analysis in Data Science, AI machine and enveloping applications for real world problems.
PO6	**Societal Implication**	Understand the role of statistics in the society and apply the same to solve the real- life problems for societal and environmental concerns.
PO7	**Environment and Sustainability**	Understand the significance of preserving the environment towards sustainable development.
PO8	**Ethics**	Continue to enhance the knowledge and skills in applied statistics and data analytics for constructive activities and demonstrate highest standards of professional ethics.
PO9	**Individual and Team Work**	Use the research-based knowledge, and machine learning techniques to analyse and solve advanced problems in data sciences through individual and group projects related to the field of Statistics and data science.
PO10	**Communication**	Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.
PO11	**Leadership Skills**	Understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments.
PO12	**Life Long Learning**	Students will be proficient in statistical analysis of data, building and assessment of different statistical models, handle statistical programming software, data management and using the concepts of statistics in real life context.
PSO1		Equip graduates with analytics and problem-solving techniques.

PSO2		Graduates will get sustainable development by using mathematical and Statistical tools.
PSO3		Focus on statistical and data science and its applications.
PSO4		Graduate will Capable to design and conduct experiments, as well as analyse and interpret data.

Course Title	**Probability Theory and Distributions**
Course Code	**SDS21096**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To make students understand the fundamental and key concepts of basic probability theory
- To enable students to gain proficiency in identifying and working with different types of random variables
- To enable students to compute and interpret the expected value of random variables
- To develop the skills to apply advanced techniques such as covariance, correlation coefficients, and linear regression
- To analyse relationships between random variables and interpret the results in a meaningful way

Course Outcomes:

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

CO1: Define related terms of probability, random variables, and expectations
CO2: Interpret the theorem related to probability theory and distributions
CO3: Apply laws of probability and expectations in real-life problems
CO4: Categorize different discrete and continuous distribution of random variables using their fundamental properties

Course Description:

This course provides a comprehensive introduction to the foundational concepts and principles of probability theory and distributions. It is designed for students with a background in mathematics, statistics who seek to deepen their understanding of random variables, probability distributions, and their applications in real-world scenarios. By the end of this course, students will be equipped with the theoretical knowledge and practical skills necessary to analyze and interpret probabilistic data, laying the groundwork for further studies in statistics and data science.

Course Content:

Module I:

Definitions and review of Probability concepts, Bonferroni's inequality, Boole's inequality, Conditional Probability, Independent Events, Bayes' Theorem and its applications.

Module II:

Random variables, distribution functions, probability mass function, probability density function, Transformation of random variable, related theorems, Random vector and joint distribution, marginal distribution, conditional distribution, Independency

Module III:

Expected value of a random variable, properties of expectation, measures of central tendency, dispersion, Moments, Skewness and Kurtosis, Moment generating function and its limitations, properties and uniqueness theorem of moment generating function

Conditional expectation, covariance, correlation coefficient, linear regression

Module IV:

Discrete probability distributions: Binomial, Poisson, negative binomial, geometric, and hyper-geometric distributions and their moment-generating functions and properties.

Continuous probability distributions: Triangular, Exponential, Normal, Gamma, Weibul, logistic distributions their moment generating functions and applications.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. Vijay K. Rohatgi, A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, 2nd edition, Wiley

T2. G Casella and R L Berger, Statistical inference, 2nd edition, Duxbury Thomson Learning

T3. S C Gupta and V K Kapoor, Fundamentals of Mathematical Statistics, S Chand & Sons

Reference Books:

R1. R. V. Hogg, J Mckean, A T Craig, Introduction to Mathematical Statistics, 7e, Pearson Education India

R2. S. Ross, A First Course in Probability, Pearson Education

R3. S. Ross, Introduction to probability models, Academic Press, Indian Reprint 2007

Course Title	**Problem Solving and Applications**
Course Code	**MTH23071**
Credit	**3**
Contact Hours (L-T-P)	**2-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To learn the technique for solving a problem systematically
- Gaining knowledge to solve a new problem from the experience of the old one
- To understand the role of a teacher/ guide in context with problem solving

Course Outcomes:

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

CO1: Define George Polya's 4-phase method.
CO2: Compare problem-solving heuristics.
CO3: Solve simple and complicated problems using the 4-phase method
CO4: Make use of the basic concept of game theory

Course Description:

If you able to solve a problem, you will get the feelings of great discovery and joy. Our life is full of problems and by solving one after another we proceed further. The problems are very much familiar with science subjects specially mathematics. By seeing books or other sources, temporarily we may able to solve some problem but that technique of problem solving is more important than solving a problem itself. This course will provide the students a step-by-step method to solve a problem effectively.

Course Content:

Module I:

Polya's four phases of problem-solving; problem understanding, devising a plan (connection between data and unknown), executing the plan, and looking back.

Module II:

Exposure to problem-solving heuristics, analogy, auxiliary problems, organizing data, decomposing and recombining, generalization, specialization, solving smaller / simpler instances, induction, combinatorics, visual representation, extreme case consideration

Module III:
Simple and challenging problems from numbers and properties; parity; counting, boys and girls, bridge hands; graphs; computational mathematics;

Module IV:
Strategic games, hundred coins, sprouts, Nim; Recreational mathematics, chessboard, cryptarithms, magic squares, weighing, logical reasoning.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. G Polya, How to Solve it?: New Aspect of Mathematical Method, Prentice Hall India, 2007
T2. Steven G Krantz, Techniques of Problem Solving, American Mathematical Society, 1997.

Reference Books:

R1. Dmitri Fomin, Sergey Genkin, and Ilia Itenberg, Mathematical Circles (Russian Experience), American Mathematical Society, 1996
R2. Shailesh Shirali, Adventures in Problem Solving, University Press, 2002
R3. Posamentier Alfred, Problem Solving Strategies in Mathematics, World Scientific Press, 2015.

Course Title	**Linear Algebra**
Course Code	**MTH21109**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To develop the idea of Vector space, subspace, basis and dimensions and linear transformation
- To develop the knowledge of Diagonalization, Eigenvalue and eigenvector
- To develop the fundamental knowledge of canonical form, bilinear form, quadratic form, Hermitian form
- To develop an understanding of Inner product space, Orthogonality and linear operators on inner product space

Course Outcomes:

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

CO1: Explain the concept of vector spaces, subspaces, and linear transformations
CO2: Solve a system of linear equations
CO3: Develop the working process within the Inner product spaces
CO4: Analyze the properties of a matrix using different factorization methods
CO5: Extend the knowledge in different forms of a matrix

Course Description:

This course includes the concept of vector spaces and linear transformations with representation. This course has the depth concept of minimal polynomial and diagonalization. Rational canonical form and Jordan canonical forms have been discussed in this course. There is a detailed discussion on Hilbert space also.

Course Content:

Module I:

Vector space, Vectors in $\mathbb{R}^n$, linear independence and dependence, linear span of a set of vectors, subspaces, basis, dimension, row space, column space, determinant, rank of matrix, Systems of linear equations, application to Geometry, Gauss elimination

Module II:

Linear transformations, matrix of a linear transformation, change of basis and similarity, Kernel and range of a transformation, rank-nullity theorem;

Inner product space, projection, orthonormal bases, Gram-Schmidt process, least squares approximation, orthogonal and positive definite matrices, complex Inner product space

Module III:

Eigenvalues and eigenvectors, characteristic polynomials, eigenvalues of special matrices, diagonalization, orthogonal diagonalization, spectral theorem for real symmetric matrices; singular values of matrix, singular value decomposition, four subspaces of a transformation

Module IV:

Triangular form, invariance, invariant direct-sum decompositions, Jordan canonical form, rational canonical form, Quotient spaces.

Bilinear forms, symmetric bilinear forms, quadratic forms, real symmetric bilinear forms, Hermitian Forms

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. G. Strang, Introduction to Linear Algebra, Fifth Edition, 2016
T2. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India)
T3. S. Lang, Algebra, 3rd Ed., Springer (India)

Reference Books

R1. P. Lax, Linear Algebra, John Wiley & Sons, New York. Indian Ed.
R2. H.E. Rose, Linear Algebra, Birkhauser
R3. Seymour Lipschutz and Marc Lipson, Schaum's Outline of Linear Algebra, 3rd Edition, 2017

Course Title	**Applied Statistics I**
Course Code	**SDS21049**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To teach the concepts of trend and forecasting.
- To guide the students with the concepts of theory and uses of index numbers.
- To give the students a perspective to the various tools useful for process and quality control.
- Be acquainted with the interdisciplinary nature of demography, and population studies

Course Outcomes:

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

CO1: Classify the concept of time series analysis
CO2: Apply the various techniques of time series analysis in forecasting
CO3: Build the concept index numbers and their uses
CO4: Make use of control charts in production process monitoring
CO5: Develop in-depth knowledge of the interdisciplinary nature of demography, measures of mortality and fertility, and concepts of life table

Course Description:

The course is designed to make the students familiar with the applied statistical and forecasting techniques. The focus of this paper is to enable the students to apply relevant tools in forecasting, quality control, economy, and population studies. As a part of the curriculum, students will be exposed to relevant tools to be applied in real life situations. At the end students are expected to identify the methods and tools to be used for real life economic, business, climate, industrial, and demographic data analysis.

Course Content:

Module I: Time Series Analysis

Components of Time Series, Decomposition of Time Series, Additive and Multiplicative model with their merits and demerits, Illustrations of Time Series, Measurement of Trend by method of free-hand curve, method of Moving Averages and method of least squares (linear, quadratic and modified exponential), Measurement of Seasonal Variations by methods of Ratio to Moving Average and Ratio to Trend.

Module II: Index Numbers

Definition, Criteria for a good Index Number, different types of Index Numbers, Construction of Index Numbers of prices and quantities, Paasche, Laspeyres and Fisher indices, Link and changes of base periods, Consumer Price Index Number, Uses and limitations of Index Numbers

Module III: Statistical Quality Control

Importance of statistical methods in industrial research and practice. Causes of variations in quality: chance and assignable. Process & Product Control. General theory of Control Charts, Control charts for Variables: X-bar and R-charts, X-bar and s-charts. Control charts for Attributes: np, p, and c-charts. Determination of Tolerance and Specification Limits

Module IV: Demographic Methods

Introduction, measurement of population, Rates, and Ratios of Vital Events. Measurement of Mortality: CDR, SDR (w.r.t. Age and sex), STDR, IMR. Life (Mortality) tables: definition of its main functions and uses. Measurement of Fertility and Reproduction: CBR, GFR, SFR, TFR. Measurement of Population Growth: GRR, NRR

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. P. Mukhopadhyay, Applied Statistics, New Central Book Agency, Calcutta, 1999.

Reference Books:

R1. A M Gun, M K Gupta, and B Dasgupta, Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata, 2008.

R2. S C Gupta, and V K Kapoor, Fundamentals of Applied Statistics, 4th Edition, Sultan Chand & Sons, 2008.

R3. D C Montogomery, Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd., 2009.

Course Title	**Applied Statistics I Lab**
Course Code	**SDS22093**
Credit	**2**
Contact Hours (L-T-P)	**0-0-4**
Course Type	**Practical**

Course Objectives:

The objectives of this course are as follows:

- To teach the students how to apply the different techniques of analysis of Trend and Seasonal Variations to Time Series datasets
- To make the students aware about the different applications of Index Numbers
- To give the students a perspective to the various tools useful for process and quality control
- To make the students be acquainted with the different aspects of Demographic data such as Mortality, Fertility, Reproduction etc.

Course Outcomes:

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

CO1: Apply the different techniques of analysis of Trend and Seasonal Variations to Time Series datasets

CO2: Build knowledge of the different applications of Index Numbers

CO3: Construct different Control Charts for Variables and Attributes

CO4: Develop in-depth knowledge of the different aspects of Demographic data such as Mortality, Fertility, Reproduction

Course Description:

The course is designed to make the students familiar with the Applied statistical and forecasting techniques. The focus of this paper is to enable the students to apply relevant tools in Time Series, Economy, Quality control and Population Studies. As a part of the curriculum, students will be exposed to relevant tools to be applied in real life situations. At the end students are expected to identify the methods and tools to be used for real life economic, business, climate, industrial and demographic data analysis.

Course Content:

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

Sl. No.	Name of the Experiments
1	Plotting a real-life Time Series and detecting various features (Trends, periodic behaviors, etc.)

2	Fitting and plotting of mathematical curves: Linear, Parabolic, Exponential and Modified Exponential
3	Fitting of Trend by Moving Average Method.
4	Measurement of Seasonal indices Ratio-to-Moving Average method.
5	Measurement of Seasonal indices Ratio-to-Trend method.
6	Calculation of Price and Quantity Index Numbers.
7	Applications on Chain Index Numbers.
8	Applications on Consumer Price Index Number.
9	Construction and interpretation of Statistical Control Charts.
10	Control Charts for Variables: X-bar and R-charts, X-bar and s-charts.
11	Control Charts for Attributes: np, p, c and u-charts.
12	To calculate CDR and Age Specific Death Rate for a given set of data.
13	To find Standardized Death Rate by: a. Direct method b. Indirect method.
14	To construct a Complete Life Table.
15	To fill in the missing entries in a Life Table.
16	To calculate CBR, GFR, SFR, and TFR for a given set of data.
17	To calculate GRR and NRR for a given set of data and compare them.

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended:

1. P. Mukhopadhyay, Applied Statistics, New Central Book Agency, Calcutta, 1999.
2. A M Gun, M K Gupta, and B Dasgupta, Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata, 2008.
3. S C Gupta, and V K Kapoor, Fundamentals of Applied Statistics, 4th Edition, Sultan Chand & Sons, 2008.
4. D C Montogomery, Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd., 2009.

Course Title	**Calculus and Optimization**
Course Code	**MTH21110**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To enable students to understand the applications of techniques from differential calculus
- To enable students to Develop the ability to model and formulate optimization problems
- To enable students to Explore and implement numerical optimization techniques, including gradient-based, to solve complex optimization problems effectively
- To cultivate analytical thinking and problem-solving skills through the application of mathematical theories and computational techniques to a variety of optimization scenarios

Course Outcomes:

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

CO1: Explain different terms of differential calculus

CO2: Classify the critical points of an optimization problem

CO3: Make use of the appropriate methodology for solving the problems related to linear programming

CO4: Explain different numerical optimization techniques

Course Description:

This course provides an in-depth exploration of optimization techniques fundamental to various scientific and engineering disciplines. It is divided into three modules, each designed to build upon the previous one, allowing students to develop a robust understanding of both theoretical concepts and practical applications. Throughout the course, students will engage in problem-solving exercises and real-world applications, fostering critical thinking and analytical skills necessary for successful careers in optimization and related fields.

Course Content:

Module I:

Functions of One Variable, Limits, Continuity, Differentiability, Derivatives, Tangents, linear approximation, Critical points, local maxima and minima;

Multivariable functions, Partial derivatives, Chain rule, Limit, Continuity, Differentiability, Directional derivatives, Directional ascent and descent, Tangent (hyper) plane, Linear approximation, Critical points - The directional of steepest ascent/descent, Higher order partial

derivatives, Hessian Matrix and local extrema, method of Lagrange multiplier, Karush-Kuhn-Tucker theory

Module II:

Modelling and formulation of optimization problems, Mean square (distance) minimizations, linear programming, Graphical method, Simplex algorithm, Revised simplex method, Duality and dual simplex method, Interior point method, transportation and assignment problems, Software packages for solving linear programming problems

Module III:

Numerical optimization techniques, line search methods, gradient methods, Newton's method, conjugate direction methods, quasi-Newton methods, projected gradient methods, and penalty methods

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Tom M. Apostol, Calculus, Volume II, 2nd Ed

T2. H. A. Taha, Operations Research: An Introduction, 10^{th} Edition, 2019

T3. J. Nocedal and S.J. Wright, Numerical Optimization, Second Edition, Springer

Course Title	**Data Analysis and Visualization with Python**
Course Code	**SDS23097**
Credit	**4**
Contact Hours (L-T-P)	**2-0-4**
Course Type	**Hybrid**

Course Objectives:

The objectives of this course are as follows:

- To develop skill of learning and utilizing Python programming.
- To learn the basic statistical measures used in data analysis.
- To acquire knowledge of different methods of data analysis using Python.
- To gain knowledge of presenting data through different types of visualizations using Python

Course Outcomes:

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

CO1: Utilize Python programming for different purposes
CO2: Build knowledge of various statistical measures used in data analysis
CO3: Make use of different techniques of data analysis
CO4: Create various types of visualization to showcase insights of data

Course Description:

The course is designed to provide students with the fundamental knowledge of analyzing different types of data through various statistical measures and visualizations. The course has four aspects – fundamentals of Python programming, theoretical knowledge of different methods and measures used in data analysis, implication of the data analysis methods using Python, data visualization techniques in Python. The course consists of theoretical lectures and hands-on practical classes.

Course Content:

Module I: Fundamentals of Python Programming

Overview of Python, Python installation, Writing codes in Python, Arithmetic operations and hierarchy, Input-output statements, Basic commands and built-in functions, Python data types, Operators, Control statements (if-else conditions), Loops (for loop, while loop), User-defined functions

Module II: Introduction to Data Analysis

Continuous variables, Discrete variables, Multivariate categorical variables, Temporal data, Spatial data, Method of collection and presentation of data, Population and Sample, Different types of data; Measures of central tendency, dispersion, and asymmetry; covariance and correlation; simple and multiple regression

Module III: Data Analysis using NumPy and Pandas

Import and export of data files, Data cleaning, handling missing values, Detection of outliers, Data scaling and normalization, Grouping data values into bins, Converting categorical variables into numerical quantitative variables Basic descriptive statistical analysis (measures of central tendency, dispersion, asymmetry), Analysis of bivariate data, Correlation, Fitting linear and nonlinear regression models, RMSE

Module IV: Data Visualizations

Overview of different types of data visualizations in Python, Data visualization libraries, Plotting with MatplotLib, Simple Line Plots, Simple Scatter Plots, Density and Contour Plots, Histograms, Binnings, and Density, Customizing Plot Legends, Customizing Colorbars, Text and Annotation, Three-Dimensional Plotting in Matplotlib, Geographic Data with Basemap, Visualization with Plotly and Seaborn

Practical Topics:

1. Python installation, Writing codes in Python, Arithmetic operations and hierarchy,
2. Input-output statements, Basic commands and built-in functions,
3. Python data types – Number, Casting, Booleans, String
4. Python data types – Lists, Tuples
5. Python data types – Sets, Dictionaries
6. Python operators, Control statements (if-else conditions)
7. Python Loops (for loop, while loop)
8. Writing user-defined functions
9. Use of NumPy
10. Array operations
11. Use of Pandas
12. DataFrames in Python
13. Import and export of datafiles
14. Data preprocessing
15. Computing basic descriptive statistical measures
16. Simple plots with MatplotLib

17. Advanced plots with MatplotLib
18. Customizations in the plots
19. Visualization with Seaborn package
20. Use of Plotly package

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Books Recommended:

1. Wes McKinney, Python for data analysis: data wrangling with pandas, NumPy, and Jupyter, 2022.
2. J W Tukey, Exploratory data analysis (Vol. 2), 1977.
3. Phuong Vo.T.H, Martin Czygan, Ashish Kumar, Kirthi Raman, Python: Data Analytics and Visualization, Packt Publishing, 2017.
4. Dr. Ossama Embarak, Data Analysis and Visualization Using Python, Apress, 2018
5. Haider, M. Getting Started with Data Science: Making Sense of Data with Analytics. IBM Press.

Course Title	**Sampling Theory**
Course Code	**SDS21098**
Credit	**3**
Contact Hours (L-T-P)	**2-0-2**
Course Type	**Hybrid**

Course Objectives:

Objective of the course is to enable students to effectively apply sampling theory and distributions in various statistical contexts, enhancing their analytical skills and understanding of inferential statistics.

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 of the exact Sampling Distributions of χ^2, t and F

CO3: Illustrate the method of finding Sampling Distributions from Univariate and Bivariate Normal populations

CO4: Solve problems related to Order Statistics and distributions of Sample Median and Sample Range

Course Description:

This course offers a comprehensive exploration of sampling theory and its applications in statistical analysis. It is designed for students who wish to deepen their understanding of sampling distributions, their properties, and practical implications. Throughout the course, students will engage in theoretical discussions, practical applications, and problem-solving exercises to develop a robust understanding of sampling theory. By the end, participants will be equipped to apply these concepts effectively in various statistical contexts, enhancing their analytical skills in data-driven decision-making.

Course Content:

Module I: Introduction to sampling theory

Introduction, population & parameter, random sample & statistic, sampling distribution of a statistic and its applications, standard error of a statistic, sampling distributions for functions of random variables – cdf technique, generating functions technique, transformation of variables technique with examples

Module II: Exact sampling distributions

χ^2 distribution and its p.d.f. with n degrees of freedom (d.f.), mean, variance, m.g.f., additive property of χ^2distribution; Student's and Fisher's t-distributions, derivation of p.d.f., mean, variance and limiting form of t distribution; Snedecor's F-distribution, derivation of p.d.f., mean, variance. Distribution of 1/F (n1, n2).

Nature of p.d.f. curve with different degrees of freedom for t, F and χ^2 distributions. Relationship between t, F and χ^2 distributions. Applications of t, F and χ^2 distribution in testing of significance problems

Module III: Sampling distributions from normal population

Derivation of the sampling distribution of sample mean and variance from a univariate normal population. 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

Module IV: 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, application of order statistic

List of experiments (to be executed using R-programming/MS Excel):

Sl. No.	**Name of the Experiments**
1	Simple random sampling with replacement and without replacement.
2	Testing of significance and confidence intervals for single proportion and difference of two proportions
3	Testing of significance and confidence intervals for single mean and difference of two means for independent samples.
4	Testing of significance and confidence intervals for the difference of two means for paired samples (paired t-test).
5	Testing of significance and confidence intervals for single variance and difference of two variances.
6	Testing of significance and confidence intervals of an observed sample correlation coefficient.
7	Chi-square test for goodness of fit.

8 Chi-square test for independence.

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

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

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

References:

R1. Mood A.M., Graybill F.A. and Boes D.C. (2007): Introduction to the Theory of Statistics, 3rd 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.

Course Title	**Machine Learning and Applications**
Course Code	**SDS21058**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To develop the student's ability to build machine learning algorithm for real life challenges.
- To educate students about different supervised and unsupervised machine learning algorithms
- To allow students to understand, interpret and process raw data

Course Outcomes:

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

CO1: Illustrate Supervised Learning Algorithms
CO2: Apply Feature Extraction Techniques to data
CO3: Develop Clustering algorithms
CO4: Evaluate Error functions for learning algorithms
CO5: Build Reinforcement learning algorithms

Course Description:

This course is aimed to develop a student's ability to build machine learning algorithm for real life challenges. Students will learn about different supervised and unsupervised machine learning algorithms. They will also be able to understand, interpret, and process raw data and perform feature extraction techniques.

Course Content:

Module I: Supervised Learning

Introduction, Machine-learning basics, Classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier, Naive Bayes classifier, Bagging, Boosting, Improving classification with the AdaBoost algorithm, Artificial Neural Network

Module II: Forecasting and Learning Theory

Predicting numeric values: regression, Linear Regression, Logistic regression, Tree-based regression, Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, Vapnik–Chervonenkis (VC) dimension, Worst case (online) learning

Module III: Unsupervised Learning

Grouping unlabeled items using k-means clustering, Association analysis with the Apriori algorithm, efficiently finding frequent itemsets with FP-growth

Module IV: Reinforcement learning

Markov decision process (MDP), Bellman equations, Value iteration, and policy iteration, Linear quadratic regulation, Linear Quadratic Gaussian, Q-learning, Value function approximation, reinforcement

Module V: Dimensionality reduction

Feature extraction - Principal component analysis, Singular valuedecomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods. Machine Learning for Big Data: Big Data and Map Reduce

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. E. Alpaydin, Introduction to Machine Learning, MIT Press Edition, 2nd Edition, 2009.
T2. T M Mitchell, Machine Learning, McGraw-Hill, 1997.
T3. P Harrington, Machine learning in action, Manning Publications Co, 2012.
T4. C M Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Reference Books

R1. Machine Learning for Big Data, J. Bell Publisher Wiley, 2014.
R2. Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning, Cambridge University Press, 2017. [http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/]
R3. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning, 2nd Edition, 2009. [https://web.stanford.edu/~hastie/ElemStatLearn/]

R4. Avrim Blum, John Hopcroft and Ravindran Kannan, Foundations of Data Science, January 2017. [https://www.cs.cornell.edu/jeh/book.pdf]
R5. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2006. [http://www.springer.com/in/book/9780387310732]

Course Title	**Machine Learning and Applications Lab**
Course Code	**SDS22059**
Credit	**2**
Contact Hours (L-T-P)	**0-0-4**
Course Type	**Practical**

Course Objectives:

The objectives of this course are as follows:

- To enable students to make use of data sets in implementing the machine learning algorithms
- To enable students to implement the machine learning concepts and algorithms in any suitable language of choice

Course Outcomes:

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

CO1: Develop the various machine learning algorithms for regression, classification, clustering, and dimension reduction problems

CO2: Apply appropriate Machine Learning algorithms and evaluation metrics for a given data set

CO3: Identify and apply appropriate Machine Learning algorithms to solve real-world problems

CO4: Design Python programs for various Learning algorithms

Course Description:

Machine Learning is concerned with computer programs that automatically improve their performance through experience. This course covers the theory and practical algorithms for machine learning from a variety of perspectives. We cover topics such as FIND-S, Candidate Elimination Algorithm, Decision tree (ID3 Algorithm), Backpropagation Algorithm, Naïve Bayesian classifier, Bayesian Network, k-Means Algorithm, k-Nearest Neighbour Algorithm, Locally Weighted Regression Algorithm.

Course Content:

Description / Instructions:

i) The programs can be implemented in Python.

ii) Data sets can be taken from standard repositories (https://archive.ics.uci.edu/ml/datasets.html) or constructed by the students.

Module I

Lab Experiments:

1. Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.
2. Write a program for linear and nonlinear regression to fit a set of data points. Select an appropriate data set for your experiment, evaluate the model and draw graphs.
3. Write a program to classify the given data set using Support vector machine and evaluate the performance of the model.
4. Write a program to demonstrate the working of the decision tree-based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
5. Write a program to implement the naïve Bayes classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering a few test data sets.
6. Assuming a set of documents that need to be classified, use the naïve Bayesian Classifier model to perform this task. Built-in Java classes/API can be used to write the program. Calculate the accuracy, precision, and recall for your data set.
7. Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.
8. Write a program to implement k-Nearest Neighbour algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.
9. Write a program to implement the principal component analysis for a high dimensional data for a given data set.
10. Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.

Module II

Implantation (through mini project) of ML concepts

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. E. Alpaydin, Introduction to Machine Learning, MIT Press Edition, 2nd Edition, 2009
T2. T M Mitchell, Machine Learning, McGraw-Hill, 1997
T3. P Harrington, Machine learning in action, Manning Publications Co, 2012
T4. C M Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Reference Books:

R1. Machine Learning for Big Data, J. Bell Publisher Wiley, 2014
R2. Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning, Cambridge University Press, 2017. [http://www.cs.huji.ac.il/~shais/UnderstandingMachineLearning/]
R3. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning, 2nd Edition, 2009. [https://web.stanford.edu/~hastie/ElemStatLearn/]
R4. Avrim Blum, John Hopcroft and Ravindran Kannan, Foundations of Data Science, January 2017. [https://www.cs.cornell.edu/jeh/book.pdf]
R5. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2006. [http://www.springer.com/in/book/9780387310732]

Course Title	**Statistical Inference**
Course Code	**SDS21050**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To explain the properties of a good estimator
- To guide the students with the various estimation methods
- To introduce the students with hypothesis testing and non-parametric methods.

Course Outcomes:

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

CO1: Compare the various properties of estimators
CO2: Build knowledge of various methods of estimation
CO3: Examine the applications of interval estimation and testing of hypothesis
CO4: Analyze the various tests and confidence intervals in appropriate situation

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.

Course Content:

Module I:

Estimation Theory: Estimation: Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency, Completeness and exponential family Estimation, Rao-Blackwell theorem, Lehman Schaffer theorem, Cramer-Rao inequality minimal sufficiency, Ancillary statistics, Basu's theorem on independence of Statistics

Module II:

Methods of estimation and criterion for good estimators Bhattacharya bound, Chapman Robbins and Kiefer (CRK) bound, maximum likelihood estimation, Zehna theorem for invariance, Cramer theorem for weak consistence, asymptotic normality, BAN and CAN estimators, asymptotic efficiency

Module III:

Confidence Estimation and Hypothesis Testing: Simple and composite hypotheses. Randomized and nonrandomized tests, Most powerful test, Neyman-Pearson Lemma and its applications, Determination of minimum sample size to achieve the desired strengths. Composite hypotheses: Monotone likelihood ratio property, power function of a test, existence of UMP, Tests for one-sided alternatives. UMP tests for two sided alternatives Examples, Their existence and non-existence

Module IV:

Generalized Neyman-Pearson lemma: Unbiased test, UMPU test and their existence in the case of exponential families, similar tests, test with Neyman structure, problem of confidence intervals, Relation with testing of hypotheses problem, Uniformly Most Accurate (UMA) and UMAU confidence intervals, shortest length confidence intervals, Non-parametric tests, One and two sample problem; tests on U-Statistics for various hypotheses; the asymptotic distributions of the statistics involved under the null hypotheses (Statements of the theorems only), Sign test, Run test, Signed-Rank test, Wilcoxon Signed Rank test, Man-Whiteny test

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. B K Kale, A First Course on parametric Inference, Narosa, 2nd Edition

T2. V K Rohatgi, Introduction to Probability and Mathematical Statistics. Wiley Eastern Ltd. New Delhi.

Reference Books:

R1. G Casella and R L Berger, Statistical inference, 2nd edition, Duxbury Thomson Learning

R2. S C Gupta and V K Kapoor, Fundamentals of Mathematical Statistics, S. Chand and Company Pvt. Ltd., New Delhi.

Course Title	**Applied Statistics II**
Course Code	**SDS21052**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To enable the students to understand the concepts of analysis of variance.
- To guide the students with the concepts of theory and applications of design of experiments

Course Outcomes:

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

CO1: Classify the concepts of ANOVA

CO2: Demonstrate the models useful for design of experiments

CO3: Explain the analyses of the basic models in design of experiments

CO4: Outline the applications of factorial experiments and incomplete designs

Course Description:

The course is designed to make the students familiar with the design of experiments techniques. The focus of this paper is to enable the students to apply relevant tools in design and analysis. As a part of the curriculum, students will be exposed to relevant tools to be applied in real life situations. At the end, students are expected to identify the methods and tools to be used for real life data analysis.

Course Content:

Module I:

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance in one-way classified data for fixed effect models, analysis of variance in two-way classified data with one observation per cell for fixed effect models

Module II:

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations

Module III:

Factorial experiments: advantages, notations and concepts, 2^2, $2^3 \ldots 2^n$ and 3^2 factorial experiments, design and analysis, Total and Partial confounding for 2n ($n \leq 5$), 3^2. Factorial experiments in a single replicate

Module IV:

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

T2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

T3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.

Reference Books

R1. Gupta, S.Sc., Kapoor, V.K. (2008): Fundamentals of Applied Statistics. Sultan Chand & Sons, New Delhi.

R2. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.

R3. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

Course Title	**Applied Statistics II Lab**
Course Code	**SDS22094**
Credit	**2**
Contact Hours (L-T-P)	**0-0-4**
Course Type	**Practical**

Course Objectives:

The objectives of this course are as follows:

- To make students enable to apply the concepts of analysis of variance.
- To guide the students with the concepts of theory and applications of design of experiments in laboratory

Course Outcomes:

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

CO1: Apply the different techniques of Analysis of Variance to datasets

CO2: Make use of the knowledge on the analyses of basic Designs of Experiments

CO3: Build in-depth knowledge on the analyses of Unconfounded and Confounded Factorial Experiments

CO4: Outline the different applications of BIBD and its types

Course Description:

The course is designed to make the students familiar with the applications of Analysis of Variance and Design of Experiments techniques. The focus of this paper is to enable the students to apply relevant tools in design and analysis. As a part of the curriculum, students will be exposed to relevant tools to be applied in real life situations. At the end, students are expected to identify the methods and tools to be used for real life data analysis.

Course Content:

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

Sl. No.	Name of the Experiments
1	Analysis of Variance of a One-way classified data for Fixed Effects Model.
2	Analysis of Variance of a Two-way classified data with one observation per cell for Fixed Effects Model.
3	Analysis of Variance of a Two-way classified data with more than one observation per cell for Fixed Effects Model.
4	Analysis of Variance of a One-way classified data for Random Effects Model.

5 Analysis of a CRD.

6 Analysis of an RBD.

7 Analysis of an LSD.

8 Analysis of an RBD with one missing observation.

9 Analysis of an LSD with one missing observation.

10 Analysis of Split Plot and Strip Plot designs.

11 Analysis of $\mathbf{2^2}$ and $\mathbf{2^3}$ Factorial Experiments in CRD and RBD.

12 Analysis of a completely confounded two-level Factorial design in 2 blocks.

13 Analysis of a completely confounded two-level Factorial design in 4 blocks.

14 Analysis of a partially confounded two-level Factorial design.

15 Analysis of a single replicate of a $\mathbf{2^n}$ design.

16 Applications of BIBD and its types.

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended:

1. W G Cochran and G M Cox, Experimental Design, Asia Publishing House, 1959.
2. M N Das and N C Giri, Design and Analysis of Experiments, Wiley Eastern Ltd., 1986.
3. A M Gun, M K Gupta, and B Dasgupta, Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata, 2008.
4. S C Gupta, and V K Kapoor, Fundamentals of Applied Statistics, 4thEdition, Sultan Chand & Sons, 2008.
5. O Kempthorne, The Design and Analysis of Experiments, John Wiley, 1965.
6. D C Montgomery, Design and Analysis of Experiments, John Wiley, 2008.

Course Title	**Data Structures and Algorithm Design**
Course Code	**CSE21741**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To make students understand the fundamental and key concepts of data structure
- To enable students to explore the underlying theory of algorithm design
- To develop the skills to apply different types of sorting, hashing, listing algorithms

Course Outcomes:

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

CO1: Define the concepts of Dynamic memory management, data types, algorithms
CO2: Illustrate the advantages and disadvantages of specific algorithms and data structures
CO3: Solve bugs in the program, recognize needed basic operations with data structures
CO4: Interpret algorithms and data structures in terms of time and memory complexity of basic operations
CO5: Construct the computational efficiency of the principal algorithms for sorting, searching, and hashing
CO6: Solve problems like sorting, searching, insertion, and deletion of data

Course Description:

Study of advanced programming topics focused on logical structures of data as well as the design, implementation and analysis of algorithms operating on these structures. Students will gain the fundamental concept of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms.

Course Content:

Module I:

Introduction: Basic Terminologies: Elementary Data Organizations, Data Structure Operations: insertion, deletion, traversal, etc.; Analysis of an Algorithm, Asymptotic Notations, Time-Space trade-off.

Arrays: Array Definition: 1D array and 2D array, Different array operations: Insertion, deletion, traversing, etc.; Algorithms for various operations and Complexity Analysis.

Searching: Linear Search and Binary Search Techniques and their complexity analysis

Module II:

Stacks and Queues: ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation – corresponding algorithms and complexity analysis. ADT queue, Types of Queues: Simple Queue, Circular Queue, Priority Queue; Operations on each type of Queues: Algorithms and their analysis.

Module III:

Linked Lists: Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, doubly linked list: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis

Module IV:

Trees: Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees, B Tree, B+ Tree: definitions, algorithms and analysis.

Graph: Basic Terminologies and Representations, Graph search and traversal algorithms and complexity analysis, shortest paths and minimum cost spanning tree

Module V:

Sorting and Hashing: Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Ellis Horowitz, Sartaj Sahni, Fundamentals of Data Structures, Illustrated Edition, Computer Science Press

T2. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest, and Clifford Stein, Introduction to Algorithms, MIT Press.

Reference Books

R1. Mark Allen Weiss, Algorithms, Data Structures, and Problem-Solving with C++, Illustrated Edition, Addison-Wesley Publishing Company

R2. R G Dromey, How to Solve it by Computer, 2nd Impression, Pearson Education

Course Title	**Data Structures and Algorithm Design Lab**
Course Code	**CSE22742**
Credit	**2**
Contact Hours (L-T-P)	**0-0-4**
Course Type	**Practical**

Course Objectives:

The objective of the course is to teach programming (with an emphasis on problem solving) and introduce elementary data structures. The student should, at a rudimentary level, be able to prove correctness (loop invariants, conditioning, etc).

Course Outcomes:

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

CO1: Analyze the asymptotic performance of the algorithms

CO2: Illustrate Linear data structures and their applications such as Stacks, Queues, and Lists

CO3: Solve and Understand Non-Linear Data Structures and their Applications such as Trees and Graphs

CO4: Interpret searching and sorting algorithms

Course Description:

Data Structures (also called Data Structures and Algorithms in some places) is a core course in all computer science undergraduate curricula. The course is the basis for understanding several data structures and also algorithms that operate on them. The course forms the foundation for almost all computer science subjects: compilers, operating systems, databases, AI and software engineering.

Course Content:

List of Programs:

1. Write a menu-based C program to insert a node at the beginning, after a specified position, at the end of a singly linked list.
2. Write a menu-based C program to delete a node from the beginning, from a specified position, from the end of a singly linked list.
3. Write a menu-based C program to display the data part of the nodes in reverse order, reverse the list and sort the elements of a singly linked list.
4. Write a menu-based C program to insert a node at the beginning, after a specified position, at the end of a doubly linked list.

5. Write a menu-based C program to delete a node from the beginning, from a specified position, from the end of a doubly linked list.
6. Write a menu-based C program to display the data part of the nodes in reverse order, reverse the list, and sort the elements of a doubly linked list.
7. Write a menu-based C program to insert, delete, and display the operation of a linear queue by using a singly linked list.
8. Write a menu-based C program to insert, delete, and display operation of a linear queue by using an array.
9. Write a menu-based C program to implement push, pop, and display operation of a linear queue by using singly linked list.
10. Write a menu-based C program to implement push, pop, and display operation of a linear queue by using an array.
11. Write a menu-based C program to implement insert, delete, and display operation of a circular queue by using an array.
12. Write a menu-based C program to implement insert, delete, and traverse operation of a binary search tree using doubly linked list.
13. Write a menu-based C program to implement linear search, binary search, and interpolation search algorithm.
14. Write a menu-based C program to implement bubble sort, selection sort, quick sort, merge sort, insertion sort, heap sort, and radix sort algorithm.
15. Implement Tree Traversals, BFS, Graph Traversal, Shortest path, and some topics on Spanning Tree using C.

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Ellis Horowitz, Sartaj Sahni, Fundamentals of Data Structures, Illustrated Edition, Computer Science Press

T2. Thomas H Cormen, Charles E Leiserson, Ronald L Rivest, and Clifford Stein, Introduction to Algorithms, MIT Press.

Reference Books

R1. Mark Allen Weiss, Algorithms, Data Structures, and Problem-Solving with C++, Illustrated Edition, Addison-Wesley Publishing Company

R2. R G Dromey, How to Solve it by Computer, 2nd Impression, Pearson Education

Course Title	**Statistical Techniques in Data Mining**
Course Code	**SDS23099**
Credit	**4**
Contact Hours (L-T-P)	**3-0-2**
Course Type	**Hybrid**

Course Objectives:

The objectives of this course are to enable students:

- To understand the concepts of data mining
- To explain the concepts of theory and uses of neural networks and genetic algorithm
- To understand the concept of data warehousing
- To learn the concepts regression and its application

Course Outcomes:

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

CO1: Classify the concept of data mining
CO2: Apply and **analyses** the various techniques of neural networks and GA
CO3: Explain technologies of warehouse operations and inventory management
CO4: Make use of concepts of regression
CO5: Develop in depth knowledge in the interdisciplinary nature case studies and practical implementation of data mining

Course Description:

The course is designed to make the students familiar with the data mining techniques. The focus of this paper is to enable the students to apply relevant tools in neural networks, classification and discriminant analysis tools, dimension reduction & visualization techniques and cluster analysis. As a part of the curriculum, students will get exposer to relevant tools to be applied in real life situations. At the end, students are expected to identify the methods and tools to be used for real life economic, business, climate, industrial, medical etc. data mining problems.

Course Content:

Module I: Introduction to Data Mining

Introduction to Data Mining and its Virtuous Cycle, Components of data mining algorithms, Data Mining: Dredging, Snooping, and Fishing, measurement, and data

Module II: Warehouse

Introduction to Data Warehousing, Data Warehouse Design and Modeling, ETL Processes, Data Warehouse Maintenance and Optimization

Module III: Neural Networks

Multi-layer perceptron, predictive ANN model building using back-propagation algorithm, exploratory data analysis using Neural Networks, self-organizing maps, Genetic Algorithms, Case Studies

Module IV: Regression analysis

Introduction to Regression Analysis, Simple Linear Regression, Multiple Linear Regression, Diagnostics and Model Evaluation, Advanced Regression Techniques, Polynomial regression, Ridge and Lasso regression

List of Experiments:

(Use R or Python language platform to perform the following experiments)

1. Loading and Indexing Data
2. Visualization of Data using Basic Graphics Functions
3. Fitting Neural Networks
4. Exploratory Data Analysis using Neural Networks
5. Self-organizing Maps
6. Neural Networks on Simulated Data and Zip Data
7. Exploration of sample data warehouse designs
8. Designing a star schema for a sample business case
9. Fitting of Simple and Multiple linear regression
10. Implementing Advanced Regression Techniques

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

T1. T Hastie, R Tibshirani, & J H Friedman, The Elements of Statistical Learning: Data Mining, Inference & Prediction, 2nd Edition, Springer Series in Statistics, Springer-Verlag, 2009

T2. R A Johnson & D W Wichern, Applied Multivariate Statistical Analysis, 6th Edition Pearson, 2008

Reference Books:

R1. D J Hand, H Mannila, & P Smith, Principles of Data Mining, MIT Press, Cambridge, MA 2001.

Course Title	**Mathematical and Stochastic Modelling**
Course Code	**SDS21051**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are as follows:

- To explain the mathematical reasoning and properties behind various models.
- To guide the students with the various estimation methods for nonlinear models and make them familiar with several two species systems, prey predator models.
- To familiarize the students with several compartmental models and fitting of those models. Along with this, to explain the applications of time series forecasting in linear models.

Course Outcomes:

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

CO1: Compare the various nonlinear growth models

CO2: Build knowledge of various methods of estimation for nonlinear models

CO3: Examine the two species models and prey-predator models

CO4: Analyze compartmental models along with the practical fitting of mechanistic nonlinear models

CO5: Apply time series forecasting methods to nonlinear models

Course Description:

The course is based on non-linear models, their properties, and various estimation of such models. This course will help the students to assess several two species and prey predator models. Additionally, they can examine fitting of compartmental models. The students will be able to apply time series forecasting in non-linear models.

Course Content:

Module I:

Empirical and mechanistic models, nonlinear growth models like monomolecular, logistic, Gompertz, Richards, applications in agriculture and fisheries

Module II:

Nonlinear estimation: Least squares for nonlinear models, methods for estimation of parameters like Linearization, Steepest, and Levenberg Marquardt's Reparameterization

Module III:

Two-species systems, Lotka-Volterra model, Leslie-Gower and Holling-Tanner: nonlinear prey-predator models, Volterra's principle and its applications, Gause competition model

Module IV:

Compartmental modeling - First and second-order input-output systems, Dynamics of a multivariable system, Practical Fitting of mechanistic nonlinear models, Application of Schaefer and Fox nonlinear models, Fitting of compartmental models

Module V:

Application of time series forecasting in nonlinear model- Introduction to AR, MA, ARMA, ARIMA and SARIMA

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. N R Draper and H Smith, Applied Regression Analysis, 3rd Ed. John Wiley, 1998.

Reference Books:

R1. S Efromovich, Nonparametric Curve Estimation, Springer, 1999
R2. J Fan and Q Yao, Nonlinear Time Series-Nonparametric and Parametric Methods, Springer, 2003
R3. J France and J H M Thornley, Mathematical Models in Agriculture, Butterworths, 1984
R4. A C Harvey, Forecasting, Structural Time Series Models and the Kalman Filter, Cambridge Univ. Press, 1996
R5. D A Ratkowsky, Nonlinear Regression Modelling: A Unified Practical Approach, Marcel Dekker, 1983

R6. D A Ratkowsky, Handbook of Nonlinear Regression Models, Marcel Dekker, 1990
R7. G A F Seber and C J Wild, Non-linear Regression, John Wiley, 1989.
R8. B W Silverman, Density Estimation for Statistics and Data Analysis, Chapman & Hall, 1986.

Course Title	**Numerical Techniques**
Course Code	**MTH23111**
Credit	**4**
Contact Hours (L-T-P)	**3-0-2**
Course Type	**Hybrid**

Course Objectives:

The objective of the course is to enable the students to build a solid foundation in numerical methods and their applications, enabling them to tackle a variety of mathematical and computational problems effectively. They will also develop critical thinking and problem-solving skills essential for advanced studies in numerical analysis and related fields.

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 a system of linear algebraic equations

CO3: Develop the basic knowledge of interpolation

CO4: Demonstrate the concept of numerical integration and Monte-Carlo simulation

Course Description:

This course provides an in-depth exploration of numerical methods and their applications in solving mathematical problems. Designed for students in mathematics, engineering, and computer science, it covers a range of topics essential for effective numerical analysis. Through theoretical discussions, practical applications, and hands-on exercises, students will develop the skills necessary to apply numerical methods to real-world problems, enhancing their analytical abilities and preparing them for advanced studies in numerical analysis and computational sciences.

Course Content:

Module I:

Floating-point representation, Numerical error analysis, computer arithmetic, round-off errors, and loss of significance in numerical computations

Solution to Transcendental and Polynomial Equations: Iterative methods, bisection method, Regula-Falsi method, secant method, Newton-Raphson method, fixed point iteration method

Module II:

Solution of System of Linear Equations: Gauss Elimination, LU factorization, Cholesky factorization, Gauss- Jacobi and Gauss-Seidel method, Successive over-relaxation (SOR)

Module III:

Finite difference operators and their properties, Newton-Gregory interpolations, Lagrange's interpolation formula, Newton's divided difference interpolation, Spline interpolation

Module IV:

Numerical Integration using Trapezoidal rule, Simpson's rule, Newton Cotes, and Gaussian quadrature formula; Error analysis, Simulation Techniques, Random number generation, Monte Carlo Method, Importance Sampling

Practical/Lab to be performed on a computer using MATLAB/C programming:

Write and execute C/MATLAB-code for the following programs:
Name of the experiment:

1. Find a root of a non-linear equation using the Bisection method
2. Find a root of a non-linear equation using the Newton-Raphson method
3. Find a root of a non-linear equation using the fixed-point iterations method
4. Solve the system of equations using the LU decomposition method
5. Solve the system of equations using the SOR/Gauss-Seidel iteration method
6. Interpolate values using Lagrange's interpolation
7. Interpolate values using Newton's divided difference interpolation
8. Evaluate the integral using Simpson's rule
9. Random number generation
10. Monte-Carlo integration

Evaluation:

Mode of Evaluation	Theory		Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination	Comprehensive and Continuous Assessment	End Semester Examination
	25%	25%	25%	25%

Text Books:

T1. 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.

T2. S. A. Mollah, Numerical Analysis and Computational Procedures, Books & Allied (P) Ltd, 2020.

T3. B. S. Grewal, Numerical Methods in Engineering & Science with Programs in C & C++, Khanna Publications, 2013.

Reference Books:

R1. T. Veerarajan, T. Ramachandran, Numerical Methods with Programs in C, Tata McGraw-Hill Publications.

R2. S. Dey, S. Gupta, Numerical Methods, McGraw Hill Education.

R3. S. S. Sastry, Introductory Methods of Numerical Analysis. PHI Learning Pvt. Ltd, 2012.

R4. S. S. Ray, Numerical Analysis with Algorithms and Programming. Chapman and Hall/CRC, 2018.

R5. A Gupta and S C Bose, Introduction to Numerical Analysis, Academic Publishers, 2009.

Course Title	**Database Management System with SQL**
Course Code	**CSE21745**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are to enable students:

- To understand database concepts, applications, data models, schemas and instances.
- To implement the relational database design and data modelling using entity-relationship (ER) model.
- To demonstrate the use of constraints and relational algebra operations.
- To be able to use SQL in querying the database.
- To demonstrate Normalization process.
- 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 the relational model concept and illustrate the relational constraints
CO4: Build Structured Query Language (SQL) and apply it 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:

Module I: Database system architecture

Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). Data models: Entity-relationship model, network model, relational and object-oriented data models, integrity constraints, data manipulation operations. ER models: Entity Set, Relation Ship Set, Cardinality Properties, Type of Entities, Type of Keys, Aggregation, Specialization and Generalization

Module II: Relational query languages

Relational algebra, Fundamental Operations, Additional Operations. Select, Project, Cartesian Product, UNION, Set difference, Rename. Types of joining operations, Division, Intersection, Aggregate. Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server

Module III: Relational database design

Integrity Constraint, Domain Constrain, Referential Integrity, Functional Dependencies, Closure of Set, Cover and Canonical Cover, Types of Anomalies, Armstrong's axioms, Extended Armstrong's axioms, Assertions and Demons. Data Base Decomposition: Domain and data dependency, Normal forms: 1NF, 2 NF, 3 NF, BCNF, Dependency preservation, Lossless design

Module IV: Query processing and optimization

Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms. Storage strategies: Indices, B-trees, B+-trees, hashing, File System, Disk Organization, Physical Storage, Buffer management

Module V: Transaction processing

Failure, Recovery from Failure, Different States of Transaction, Transaction Isolation, ACID property, Serializability of scheduling, Multi-version and optimistic Concurrency Control schemes. Concurrency control: Locking and timestamp-based schedulers, 2-Phase Locking Protocol, Dead Lock, Database Security: Authentication, Authorization, and access control, DAC,

MAC and RBAC models, Intrusion detection, SQL injection. Advanced topics: Distributed databases, Data warehousing and data mining

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

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

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

Reference Books:

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

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

Course Title	**Database Management System with SQL Lab**
Course Code	**CSE22746**
Credit	**2**
Contact Hours (L-T-P)	**0-0-4**
Course Type	**Practical**

Course Objectives:

The objectives of this course are as follows:

- To explain basic database concepts, applications, data models, schemas and instances
- To demonstrate the use of constraints and relational algebra operations
- To describe the basics of SQL and construct queries using SQL
- To emphasize the importance of normalization in databases
- To facilitate students in Database design
- 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: Familiarization of structured query language.

Experiment 2: Table Creation.

Experiment 3: Insertion, Updation, and Deletion of tuples.

Experiment 4: Executing different queries based on different functions.

Experiment 5: Performing joining operations.

Experiment 6: Nested Queries.

Experiment 7: Use of aggregate functions.

Experiment 8: Use of group functions.

Experiment 9: Use of order by functions.

Experiment 10: Arithmetic operations.

Experiment 11: Trigger using SQL.

Experiment 12: Introduction to PL/SQL.

Experiment 13: Report generation of various queries.

Experiment 14: Merging databases with the front end using ODBC connection.

Experiment 15: SQL Injection on a non-harmful test page

Evaluation:

Mode of Evaluation	Practical	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

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

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

Reference Books:

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

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

Course Title	**Summer Internship (Industry/Institute visit)**
Course Code	**SDS24060**
Credit	**2**
Contact Hours (L-T-P)	
Course Type	**Internship**

Course Objectives:

To apply the knowledge of statistics and data science in relevance to practical solutions.

Course Outcomes:

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

CO1: Apply techniques using different methods of applying skills and knowledge acquired in the classroom.

CO2: Understand the professional requirements for access to and success in the field.

CO3: Realize the work ethic and skills required for success in the field.

Course Description:

Summer internship allows the student an opportunity to bridge theory and practice. 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 (research and development, teaching, 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.

Evaluation:

Mode of Evaluation	Presentation and Report
Weightage	End Semester Examination
	100%

Course Title	**Minor Project**
Course Code	**SDS24061**
Credit	**2**
Contact Hours (L-T-P)	
Course Type	**Project**

Course Objectives:

- To address the real world problems and find the required solution
- To fabricate and implement the mini project intended solution for project based learning
- 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: Identify the requirements for the real-world problems.
CO2: Demonstrate the project successfully by theoretical review and analysis.
CO3: Study and enhance software skills.
CO4: Explain the findings of the study conducted in the preferred domain

Course Description:

The role of Minor Projects in life of Science students are very crucial. Minor Project helps you to explore and strengthen the understanding of fundamentals through practical application of theoretical concepts. Everything around you is being explained by our greatest Mathematicians to date. In this article we, will be covering what is applied mathematics and mini-projects that can be done by the students during their academics. It acts like a beginners guide to do larger projects later in their career. It not just affects the grades of Engineering 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.

Evaluation:

Mode of Evaluation	Presentation and Report
Weightage	End Semester Examination
	100%

Course Title	**Artificial Intelligence and Applications**
Course Code	**CSE21751**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The main objective is to enable the students to have comprehensive understanding of artificial intelligence concepts, techniques, and applications, equipping them with the skills necessary to tackle complex problems in various domains

Course Outcomes:

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

CO1: Learn the fundamentals of AI

CO2: Understand Problem Solving, Search and Control Strategies

CO3: Examine logic and reasoning methods from a computational perspective

CO4: Learn about agent, search, probabilistic models, perception and cognition, and ML

CO5: Learn about state-of-the-art technologies like Deep Learning, Human-Computer Interaction, and Augmented Reality

CO6: Use AI concepts

Course Description:

This course provides a comprehensive introduction to the foundational concepts and advanced techniques in Artificial Intelligence (AI). It covers the history and evolution of AI, equipping students with a strong understanding of how AI applications are developed and evaluated in real-world scenarios. The course explores various AI methodologies, including problem-solving, search algorithms, knowledge representation, and decision-making under uncertainty. Students will dive into AI's essential components, such as heuristic search strategies, adversarial search in games, and constraint satisfaction problems. They will also explore knowledge-based systems, propositional and first-order logic, and inference mechanisms that form the backbone of intelligent agents. The course emphasizes planning algorithms, probabilistic reasoning, and handling uncertainty in AI, with a focus on Bayesian networks. Practical applications include computer vision, image processing, natural language understanding, and interaction, with deep learning approaches and pre-trained models integrated into case studies. In the final module, students apply AI principles through a hands-on mini-project, where they implement and showcase their understanding of key AI concepts. Upon completion, students will be well-prepared to design,

analyze, and apply AI techniques to a variety of complex problems in modern technology and industry.

Course Content:

Module I:

Introduction to artificial intelligence: History of AI, Proposing and evaluating AI applications, Any Case study

Module II:

Problem Solving, Search and Control Strategies: General problem solving, production systems, control strategies forward and backward chaining, exhaustive searches depth first breadth-first search, Search Techniques: Informed (Heuristic) Search and Exploration, Greedy best-first search, A* search, Memory bounded heuristic search, Heuristic functions, inventing admissible heuristic functions, Local Search algorithms, Hill-climbing, Simulated Annealing, Genetic Algorithms, Online search Constraint Satisfaction Problems, Backtracking Search, variable and value ordering, constraint propagation, intelligent backtracking, local search for CSPs, Adversarial Search, Games, The minimax algorithm, Alpha-Beta pruning, Imperfect Real-Time Decisions, Games that include an Element of Chance

Module III:

Knowledge Representations: Knowledge Based Agents, Logic, Propositional Logic, Inference, Equivalence, Validity and Satisfiability, Resolution, Forward and Backward Chaining, DPLL algorithm, Local search algorithms, First Order Logic, Models for first-order logic, Symbols and Interpretations, Terms, Atomic sentences, complex sentences, Quantifiers, Inference in FOL, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution

Module IV:

Planning, Language of planning problems: Planning with state-space search, forward and backward state-space search, Heuristics for state-space search, partial order planning, planning graphs, planning with propositional logic. Uncertainty, Handing uncertain knowledge, rational decisions, basics of probability, axioms of probability, inference using full joint distributions, independence, Baye‘s Rule and conditional independence, Bayesian networks, Semantics of Bayesian networks, Exact and Approximate inference in Bayesian Networks

Module V:

Image Processing: Introduction to computer vision, Image segmentation, Object and motion detection, Object classification, Use of pre-trained models (Inception). Natural Language Understanding: Introduction to natural language understanding, Case study: Machine translation, Sentiment analysis, Application of deep learning to NLP. Natural Language Interaction: Speech recognition, Hidden Markov Models, Chatbots, Natural language generation, Speech synthesis

Module VI:

Implantation (through mini project) of AI concepts

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Russell and Norvig, A Modern Approach, Pearson Education (Low Priced Edition), 2004.

Reference Books

R1. Nils J. Nilsson, Morgan Kauffman, Artificial Intelligence: A New Synthesis, (Harcourt Asia), 2002.

Course Title	**Stochastic Process**
Course Code	**SDS21043**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

- To understand the basic components of stochastic process
- To build the knowledge about discrete-time and continuous-time Markov chain
- To understand different Queuing model
- To build the knowledge about Martingales, Brownian motion, Renewal process and Branching process

Course Outcomes:

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

CO1: Interpret probability generating function and its use in stochastic process

CO2: Explain different concepts related to the discrete-time Markov chain

CO3: Apply the knowledge of continuous-time Markov chain in real-world problem

CO4: Illustrate the concepts of Martingales, Brownian motion, Renewal process, and Branching process

Course Description:

This course provides an in-depth exploration of stochastic processes, with a focus on key mathematical and probabilistic concepts essential for modeling and analyzing random systems over time. Students will begin by reviewing foundational probability theory, including random variables, distributions, and probability-generating functions, before exploring the basic classification and types of stochastic processes. The course progresses to a detailed study of **Discrete-time Markov Chains** (DTMC), **Continuous-time Markov Chains** (CTMC) and their applications. The course also covers advanced topics such as **Martingales**, **Renewal and Branching Processes.** By the end of the course, students will be able to apply these stochastic models to real-world systems, gaining valuable skills for fields such as operations research, communication networks, finance, and engineering systems.

Course Content:

Module I:

Review of probability theory, random variable and distribution; Probability generating function and its properties, Sequence of random variables; Simple stochastic process: Definition, classification and Examples

Module II:

Discrete-time Markov chains: Introduction, Definition and Transition Probability Matrix, Chapman-Kolmogorov Equations, Classification of States, Limiting and Stationary Distributions, Ergodicity, Time Reversible Markov Chain, Application of Irreducible Markov chains in Queuing Models; Reducible Markov Chains

Module III:

Continuous-time Markov chains: Definition, Kolmogorov Differential Equation and Infinitesimal Generator Matrix, Limiting and Stationary Distributions, Birth and Death Processes, Poisson processes, M/M/1 Queuing model; Simple Markovian Queuing, Applications of Continuous-time Markov chain, Queueing networks, Communication systems, Stochastic Petri Nets

Module IV:

Martingales: Conditional expectations, definition and examples of martingales, inequality, convergence and smoothing properties

Brownian motion: Definition and Properties; Processes Derived from Brownian motion, Stochastic Differential Equation

Renewal Processes: Renewal Function and Equation, Generalized Renewal Processes and Renewal Limit Theorems, Markov Renewal and Markov Regenerative Processes, Non-Markovian Queues, Application of Markov Regenerative Processes

Branching Processes: Definition and examples branching processes, probability generating function, mean and variance, Galton-Watson branching process, probability of extinction

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. J. Medhi, Stochastic Processes, New Age International (P) Ltd., New Delhi,2nd Edition, 2001

T2. S.M. Ross, Stochastic Processes, 2nd Edition, Wiley, 1996 (WSE Edition).

Reference Books:

R1. H.M. Taylor and S. Karlin, An Introduction to Stochastic Modeling, 3rd Edition, Academic Press, New York, 1998.
R2. Liliana Blanco Castaneda, Viswanathan Arunachalam, Selvamuthu Dharmaraja, Introduction to Probability and Stochastic Processes with Applications, Wiley, 2012.
R3. G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, 3rd Edition, Oxford University Press, 2001.

Course Title	**Survival Analysis**
Course Code	**SDS21100**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objectives of this course are to enable students:

- To analyse data from studies tracking individuals until specific events (e.g., death, cure, relapse), using follow-up data for non-events
- To understand and check analytical assumptions, focusing on practical interpretation of results
- To develop skills to clearly present findings to both technical and non-technical audiences

Course Outcomes:

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

CO1: Understand time, censoring concepts, and parametric life distributions

CO2: Learn to construct life tables, analyze failure rates, mean residual life, and study various aging concepts, including Bathtub Failure Rate.

CO3: Estimate survival functions using Actuarial and Kaplan-Meier methods, and perform tests of exponentiality against non-parametric classes.

CO4: Analyze two-sample problems using tests like Gehan and Log-rank, and apply Cox's proportional hazards model for regression analysis in survival data

Course Description:

This course provides an extensive study of survival analysis and reliability theory, focusing on statistical methods used to analyze time-to-event data, with applications in fields such as biostatistics, actuarial science, and engineering reliability. The course begins with the fundamental concepts of time, order, and random censoring. Students will then study life tables, failure rates, and mean residual life functions, gaining a deep understanding of elementary properties. The course introduces the concept of ageing and explores various ageing classes, their properties, relationships, and bathtub-shaped failure rates, along with the concept of inverse hazard rates. Further, the course focuses on the estimation of survival functions. The course introduces semi-parametric regression models, particularly Cox’s Proportional Hazards (PH) model, for analyzing failure rates with covariates. Students will explore estimation problems in Cox’s model and learn about rank tests for regression coefficients. Additionally, the course covers competing risks models, focusing on parametric and non-parametric inference in these settings. By the end of the

course, students will be equipped with both theoretical concepts to perform survival analysis and reliability testing in diverse real-world applications.

Course Content:

Module I:

Concepts of time, Order and random Censoring, likelihood in these cases. Life distributions Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate. Parametric inference (Point estimation, scores, MLE)

Module II:

Life tables, failure rate, mean residual life and their elementary properties. Concept of Ageing, Types of Ageing classes and their properties and relationship between them, Bathtub Failure rate, Concept of Inverse Hazard rate

Module III:

Estimation of survival function Actuarial Estimator, Kaplan- Meier Estimator, Estimation under the assumption of IFR / DFR. Tests of exponentiality against non- parametric classes-total time on test, Despande test

Module IV:

Two sample problem- Gehan test, Log rank test. Mantel Haenszel test, Tarone Ware tests. Introduction to Semi- parametric regression for failure rate, Cox's proportional hazards (PH) model with one and several covariates and estimation problems in Cox's PH Model. Rank test for the regression coefficients. Competing risks model, parametric and non-parametric inference for this model

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Miller, R.G. (1981): Survival analysis (John Wiley)

T2. Cox, D.R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, NewYork
T3. Elisha T Lee, John Wenyu Wang and Timothy Wenyu Patt (2003): Statistical Methods for Survival data Analysis, 3/e, Wiley Inter Science.

Reference Books:

R1. Gross, A.J. and Clark, V.A. (1975) : Survival distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons
R2. Elandt Johnson, R.E. Johnson N.L.: Survival Models and Data Analysis, John Wiley and sons
R3. Kalbfleisch J.D. and Prentice R.L.(1980), The Statistical Analysis of Failure Time Data, John Wiley

Course Title	**Statistical Quality Control**
Course Code	**SDS21101**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

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:

Module I: Quality

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.

Module II: Statistical Control Charts

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.

Module III: Product Control

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.

Module IV: Six-Sigma and ISO quality standards

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.

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

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

Course Title	**Cryptography and Network Security**
Course Code	**CSE21749**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The primary objective of this course is to provide students with a deep understanding of cryptographic techniques and their application to securing modern network systems. By the end of the course, students will be able to design and analyze secure communication protocols, understand various attack vectors, and implement robust security solutions.

Course Outcomes:

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

CO1: Define the basics of OSI security model and Classical Encryption Technique

CO2: Explain and identify the application of Public Key Encryption Techniques and practices

CO3: Demonstrate the application of Data Authentication and Authorization.

CO4: Examine the basics concept of Network Security and Web Security.

CO5: Appraise the recent threats and attacks against the technical world and design some effective prevention scheme

Course Description:

This course provides a comprehensive introduction to cryptography and coding theory, focusing on both the mathematical foundations and modern cryptographic techniques. It covers essential concepts needed to understand and design secure communication systems, along with methods to detect and correct errors in data transmission. By the end of the course, students will be proficient in both theoretical and practical aspects of cryptography and coding theory, equipping them to apply these concepts in securing data and communication systems.

Course Content:

Module I: Mathematical Preliminaries

Modular arithmetic, Division theorem, Equivalence relation, Residue class, GCD and its properties, Euler-Toient Function, Fermat's Little Theorem, Groups, Abelian Groups, Monoids, Group isomorphisms, Ring, Field

Module II:

Analyzing Unconditional Security: Plaintext Distribution, Key Distribution, Ciphertext Distribution, Attacker's Probabilities, Condition for Perfect Secrecy, Mechanism of Twisted Shift

Cipher, Shannon's Theorem, One Time Pad (Verman's Cipher), and Limitations of Perfect Secrecy.

Quantification of Information: Entropy, Entropy and Coding, Measurement of the Redundancy in a Language, Conditional Entropy, Joint Entropy, Entropy and Encryption, Unicity Distance.

Classical Cryptosystems: Ciphers, Symmetric Algorithms, Asymmetric Algorithms, Encryption, Attacker's Capabilities, Kerckhoff's Principle for cipher design, Shift Cipher, Substitution Cipher, Polyalphabetic Ciphers, Vigenère Cipher, Affine Cipher, Hill Cipher, Permutation Cipher, Block Ciphers, Stream Ciphers, Product Ciphers, Affine Cipher, Idempotent Ciphers, Iterative Cipher

Module III:

Public key Cryptosystems: One Way Functions, Trapdoor One Way Function, RSA Algorithm, RSA Encryption and Decryption, Software Implementation of RSA Algorithm using Multi-precision Arithmetic(Multi-precision Addition, Multi-precision Subtraction, Multi-precision Multiplication using Karatsuba's Algorithm, Test for Primes, Great Internet Mersenne Prime Search, Primality Tests with Trial Division, Randomized Algorithms for Primality Testing using Monte-carlo method, Finding Large Primes (using Fermat's Theorem), Fermat's Primality Test and its limitation, Strong probable-primality test, Miller-Rabin Primality Test, Miller-Rabin Algorithm (test for composites), Quadratic Residues, Legendre Symbol, Euler's Criteria, Quadratic Non Residue, Solovay Strassen Primality Test, Jacobi Symbol and its properties, Digital Signatures, Digital Certificates

Factoring Algorithms: Pollard p-1 Factorization, Pollard Rho Algorithm, ElGamal Public Key Cryptosystem, Shank's Algorithm (also known as Baby-step Giant-step)

Key Exchange Protocols: Diffie Hellman Problem

Hash Functions: Avalanche Effect, Hash Family, UnkeyedHash Function, Preimage Resistant of Hash Function (one-wayness problem), Second Preimage of Hash Function, Collision Resistance of Hash Function, Random Oracle Model, Independence Property of Hash Function, RO model and Las Vegas randomized algorithm, Birthday Paradox, Iterated Hash Functions, Merkle-Damgard Iterated Hash Function, some popular Hash Functions MD5 algorithm (MD5) and Secure Hash Algorithm 1 (SHA 1)

Module IV: Private Key Cryptosystems

Modern techniques, and algorithms like DES, AES, IDEA, RC5, Blowfish

Module V: Elementary Concepts of Coding Theory

Basic assumptions about channels (Code length preservation, Independence of errors), Basic strategy for decoding (maximal likelihood principle, nearest neighbor decoding strategy etc.), Hamming distance and its properties, Basic error correcting theorem, Binary symmetric channel, parity-check bit, two-dimensional parity code, Hadamard code, International Standard Book Number (ISBN)-code, Single error detection, Transposition detection, Equivalence of codes, Criteria for good code, The sphere-packing or Hamming bound, Gilbert-Varshanov bound, Huffman's code, Applications of Algebraic Coding Theory to Cryptography

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended:

1. Douglas Stinson, Cryptography Theory and Practice, 2nd Edition, Chapman & Hall/CRC.
2. B A Forouzan, Cryptography & Network Security, Tata Mc Graw Hill.
3. W Stallings, Cryptography and Network Security, Pearson Education.
4. Wenbo Mao, Modern Cryptography, Theory & Practice, Pearson Education.
5. Hoffstein, Pipher and Silvermman, An Introduction to Mathematical Cryptography, Springer.
6. J Daemen, and V Rijmen, The Design of Rijndael, Springer.
7. A Joux, Algorithmic Cryptanalysis, CRC Press.

S G Telang, Number Theory, Tata Mc Graw Hill.

Course Title	**Cloud Computing**
Course Code	**CSE21752**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objective of this course is to provide students with a comprehensive understanding of the concepts, architecture, and technologies behind cloud computing. Students will explore the design and deployment of cloud-based infrastructure, virtualization technologies, storage solutions, and distributed programming models. By the end of the course, students will be equipped to design, manage, and analyze cloud-based systems, addressing both technical and business perspectives.

Course Outcomes:

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

CO1: Construct a model with reduced implementation and maintenance costs.

CO2: Provide Flexible and scalable infrastructures.

CO3: Plan for a faster implementation to market.

CO4: Experiment with case studies, to understand cloud computing practice in the market

Course Description:

This course provides a comprehensive introduction to cloud computing, covering its fundamental concepts, architectures, enabling technologies, and real-world applications. It begins with an exploration of the definition and evolution of cloud computing, delving into the key service and deployment models, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Students will study the economic models and service-level agreements (SLAs) associated with cloud platforms, along with the benefits, risks, and challenges of adopting cloud-based solutions. By the end of the course, students will have the knowledge and skills to design, manage, and deploy cloud-based infrastructures and applications, leveraging modern cloud technologies to solve complex computational and business challenges.

Course Content:

Module I:

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. Topics in Cloud Security; Common cloud providers and their associated cloud stacks and popular cloud use case scenarios

Module II:

Cloud Infrastructure: Historical Perspective of Data Centres; Datacentre Components: IT Equipment and Facilities; Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power calculations, PUE (Power usage effectiveness) and Challenges in Cloud Data Centres; Cloud Management and Cloud Software Deployment Considerations

Module III:

Virtualization (CPU, Memory, I/O); Case Study: Amazon EC2; Software Defined Networks (SDN); Software Defined Storage (SDS)

Module IV:

Cloud Storage Introduction to Storage Systems; Cloud Storage Concepts Distributed File Systems (HDFS, Ceph FS); Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB); Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph),

Programming Models Distributed Programming for the Cloud; Data-Parallel Analytics with Hadoop; MapReduce (YARN); Iterative Data-Parallel Analytics with Apache Spark; Graph Parallel Analytics with Graph Lab 2.0 (Power Graph)

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books:

T1. Gautam Shroff, Enterprise Cloud Computing - Technology, Architecture, Applications, Cambridge University Press, 2010

T2. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Cloud Computing: Principles and Paradigms, Wiley,2011

Reference Books:

R1. Naresh Kumar Sehgal, Pramod Chandra P. Bhatt, Cloud Computing: Concepts and Practices, Springer 2018.

R2. Federico Lucifredi and Mike Ryan, AWS System Administration: Best Practices for Sysadmins in the Amazon Cloud, O'Reilly Media, Inc, 2018.

Course Title	**Clinical Trials and Biostatistics**
Course Code	**SDS21102**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objective of this course is to equip students with a comprehensive understanding of the statistical methods and analytical techniques essential for designing and evaluating clinical trials.

Course Outcomes:

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

- **CO1:** Understand the phases of clinical trials and implement various statistical designs, randomization methods, and blinding techniques
- **CO2:** Apply different biological assay methods and analyze dose-response relationships, including PK-PD analysis and median effective dose estimation
- **CO3:** Perform ROC curve analysis, estimate the area under the curve, and understand Kullback-Leibler Divergence and its relationship to ROC curve properties
- **CO4:** Measure disease frequency (incidence, prevalence, relative risk) and analyze epidemiological study designs (cohort and case-control) while addressing concepts of bias

Course Description:

This course introduces students to statistical methods and analytical techniques used in the design and evaluation of clinical trials and epidemiological studies. It covers the essential phases of clinical trials and the application of statistical methodologies in biological assays, dose-response analysis, ROC curve analysis, and disease frequency measures. By the end of this course, students will have acquired the statistical skills required to design, analyze, and interpret clinical trials and epidemiological studies, with practical applications in biomedical research, public health, and pharmaceutical development.

Course Content:

Module I:

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

Module II:

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

Module III:

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

Module IV:

Measures of disease frequency – incidence – prevalence – relative risk – Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – concept of bias information bias and selection bias

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Elisa T. Lee & John Wenyu Wang (2003): Statistical methods for Survival Data Analysis, 3rd Edition, John Wiley

T2. Jerrold H. Zar (1999): Biostatistical Analysis, 4 th edition, Pearson

T3. Armitage, P, Berry G and Mathews J.N.S (2002): Statistical Methods in Medical Research, 4/e, Blackwell Scientific Publications

T4. Krzanowski, W and Hand, D.J. (2009): ROC Curves for Continuous Data, Chapman and Hall

Reference Books:

R1. Hosmer and Lemeshow (2000): "Applied Logistic Regression", 2/e, Wiley Series

R2. Alan Agresti (2002): Categorical Data analysis, 2/e, John Wiley
R3. Sylvia Wasserthial and Smoller, (2004): Biostatistics and Epidemiology – A Primer for Health and Biomedical professionals, 3rd Edition, Springer
R4. Rastogi, V.B. (2006): Fundamentals of Biostatistics, ANE Books, India

Course Title	**Demography**
Course Code	**SDS21103**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The primary objective of this course is to provide students with a comprehensive understanding of demographic concepts, theories, and methodologies. By the end of the course, students will be able to analyze population dynamics, interpret demographic data, and apply demographic principles to real-world issues.

Course Outcomes:

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

CO1: Interpret demographic measures and population pyramids accurately
CO2: Construct life tables, interpret mortality data, and analyze mortality patterns effectively
CO3: Measure fertility, analyze population growth patterns and model stable populations
CO4: Estimate population size, project population growth, assess aging impacts and derive demographic measures from incomplete data

Course Description:

This course provides a comprehensive introduction to the study of demography, which is the statistical and analytical examination of human populations. Students will explore key concepts, methodologies, and theories that underpin the field of demography, enabling them to understand population dynamics and their implications for society. The course begins by defining fundamental demographic concepts such as population size, structure, distribution, and the factors driving population changes over time. Students will learn about essential demographic measures, including fertility rates, mortality rates, migration patterns, and population growth rates, providing a solid foundation for analyzing demographic trends. The course will delve into historical and contemporary demographic theories, including the demographic transition model, which explains changes in population growth and structure as societies develop economically and socially. Students will examine the interplay between demographic factors and socioeconomic variables such as education, health, and employment, gaining insight into how these factors influence population dynamics. Students will develop practical skills in collecting, analyzing, and interpreting demographic data using statistical methods and demographic software. The course will also emphasize the implications of demographic trends for public policy, urban planning, healthcare systems, and resource allocation, encouraging students to think critically about how demographic changes impact various sectors of society. Additionally, the course will explore global and regional demographic issues, including aging populations, youth bulges, migration

patterns, and urbanization. Ethical considerations in demographic research and the use of demographic data for informed policy-making will also be discussed. Through lectures, discussions, case studies, and hands-on research projects, students will apply theoretical knowledge to real-world scenarios, enhancing their understanding of population issues. By the end of the course, students will be equipped with the analytical skills and knowledge necessary to contribute to demographic research, policy development, and program implementation in fields such as public health, urban studies, and social sciences.

Course Content:

Module I:

Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Labour force participation rates, Density of population, Probability of dying

Module II:

Life tables: Construction of a life table, Graphs of lx, qx, dx, Functions Lx, Tx, and Ex. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity

Module III:

Fertility: Measures of Fertility, reproductively formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable Populations, Calculation of the age distribution of a stable population, Model Stable Populations

Module IV:

Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections. Aging of the population, Estimation of demographic measures from incomplete data

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Text Books

T1. Pollard, A. H. Yusuf, F. and Pollard, G.N. (1990). Demographic Techniques, Pergamon Press, Chapters 1-8, 12.

Reference Books

R1. Keyfitz, N. (1977) Applied Mathematical Demography A Willey-Interscience Publication

R2. Keyfilz, N. (1968) Introduction to the Mathematics of Population Ready, Mass: Addition Wesley

R3. Keyfilz, N. and Caswell, H. (2005) Applied Mathematical Demography, Third edition, Springer

Course Title	**Big Data Analytics**
Course Code	**SDS21062**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objective of this course is to provide students with a comprehensive understanding of big data analytics concepts, tools, and techniques. By the end of the course, students will be equipped to analyze and interpret large datasets to drive decision-making in various domains.

Course Outcomes:

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

CO1: Identify Big Data and its Business Implications
CO2: List the components of Hadoop and Hadoop Eco-System
CO3: Outline and Process Data on Distributed File System
CO4: Plan Job Execution in Hadoop Environment
CO5: Develop Big Data Solutions using Hadoop Eco System
CO6: Illustrate Infosphere Big Insights Big Data Recommendations

Course Description:

This course provides an in-depth exploration of big data analytics, focusing on the concepts, technologies, and methodologies used to analyze vast amounts of data to uncover valuable insights. As organizations increasingly rely on data to inform their decisions, this course equips students with the skills necessary to navigate the complexities of big data. The course begins by defining big data and its core characteristics—volume, velocity, variety, veracity, and value. Students will learn about the significance of big data analytics in various sectors and how it transforms data into actionable insights. Key technologies in big data analytics, including Hadoop, Apache Spark, and NoSQL databases, will be thoroughly examined. Students will explore the architecture of these technologies and their practical applications in processing and analyzing large datasets. Hands-on experience will be a crucial component of the course, where students will engage in data preparation, cleaning, and transformation techniques essential for effective analysis. The course will also cover statistical methods and machine learning algorithms applicable to big data, such as regression analysis, classification, clustering, and recommendation systems. Data visualization techniques will be introduced to help students effectively communicate their findings. The course will emphasize the importance of visual storytelling in making complex data understandable and actionable. Ethical considerations related to big data analytics, including privacy, security, and data governance, will be discussed to prepare students for the responsibilities that come with

handling sensitive information. Real-world case studies will provide students with practical insights into how big data analytics is applied across various industries, including healthcare, finance, marketing, and social media. By analyzing these cases, students will learn best practices and the challenges faced when implementing big data solutions. Through lectures, hands-on labs, discussions, and projects, students will develop the skills to design and implement big data analytics projects. By the end of the course, students will be well-prepared to leverage big data analytics to drive informed decision-making in their professional careers.

Course Content:

Module I: Introduction to big data

Introduction to Big Data Platform, Challenges of Conventional Systems, Intelligent data analysis, Nature of Data, Analytic Processes and Tools, Analysis vs Reporting

Module II: Mining data streams

Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real-time Analytics Platform (RTAP) Applications, Case Studies, Real-Time Sentiment Analysis, Stock Market Predictions

Module III: Hadoop

History of Hadoop, the Hadoop Distributed File System, Components of Hadoop Analysing the Data with Hadoop, Scaling Out, Hadoop Streaming, Design of HDFS-Java interfaces to HDFS Basics, Developing a Map Reduce Application, How Map Reduce Works, Anatomy of a Map Reduce Job run-Failures, Job Scheduling, Shuffle and Sort, Task execution - Map Reduce Types and Formats, Map Reduce Features- Hadoop environment

Module IV: Frameworks

Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive services, Hive QL, Querying Data in Hive - fundamentals of HBase and ZooKeeper, IBM InfoSphere Big Insights and Streams, Predictive Analytics, Simple linear regression, multiple linear regressions, Interpretation of regression coefficients, Visualizations, Visual data analysis techniques, interaction techniques, Systems and applications

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended:

1. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer, 2007.
2. Tom White, “Hadoop: The Definitive Guide”, Third Edition, O’Reilly Media, 2012.
3. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, “Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data”, McGraw-Hill Publishing, 2012.
4. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, CUP, 2012.
5. Bill Franks, “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, John Wiley & sons, 2012.
6. Glenn J. Myatt, “Making Sense of Data”, John Wiley & Sons, 2007.
7. Pete Warden, “Big Data Glossary”, O’Reilly, 2011.
8. Jiawei Han, Micheline Kamber “Data Mining Concepts and Techniques”, 2nd Edition, Elsevier, Reprinted 2008

Course Title	**Cyber Security for Data Science**
Course Code	**CSE21750**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objective of the course is to equip the students with the necessary skills to navigate the complex interplay between cybersecurity and data science effectively.

Course Outcomes:

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

CO1: Understand Cyber Security Fundamentals
CO2: Explain Threat Analysis and Risk Management
CO3: Illustrate Security Architecture and Design
CO4: Explain Legal and Ethical Aspects of Cyber Security

Course Description:

The Cyber Security for Data Science course provides an in-depth exploration of the intersection between cybersecurity practices and data science methodologies. This course aims to equip students with the skills necessary to safeguard data throughout its lifecycle, ensuring integrity, confidentiality, and availability. This course is designed for data scientists, analysts, and cybersecurity professionals looking to enhance their understanding of cybersecurity issues within the data science field. By the end of the course, participants will be well-prepared to implement robust security measures to protect sensitive data in their projects.

Course Content:

Module I:

Systems Vulnerability Scanning: Open Port / Service Identification, Banner / Version Check, Traffic Probe, Vulnerability Probe, Vulnerability Examples, OpenVAS, Metasploit.

Networks Vulnerability Scanning: Netcat, Socat, understanding Port and Services tools - Datapipe, Fpipe, WinRelay, Network Reconnaissance – N map, THC-A map and System tools.

Network Sniffers and Injection tools: Tcp dump and Win dump, Wireshark, Ettercap, Hping Kismet

Module II:

Network Protection tools: Firewalls and Packet Filters, Firewall Basics, Comparison between Packet Filter and Firewall, Protection mechanism of Firewall, Packet Characteristic to Filter,

Stateless and Stateful Firewalls, Network Address Translation (NAT) and Port Forwarding, the basic of Virtual Private Networks, Linux Firewall, Windows Firewall, Snort - Network Intrusion Detection and Prevention System

Module III:

Protection tools against web vulnerabilities: Nikto, W3af, HTTP utilities - Curl, OpenSSL and Stunnel, Application Inspection tools – Zed Attack Proxy, Sql map, Damn Vulnerable Web App (DVWA), Webgoat

Password Cracking and Brute-Force Tools: John the Ripper, L0htcrack, PW dump, HTC-Hydra

Module IV:

Cyber Crime and Law: Cyber Crimes, Types of Cybercrime, Hacking, Attack vectors, Cyberspace and Criminal Behavior, Clarification of Terms, Traditional Problems Associated with Computer Crime, Introduction to Incident Response, Digital Forensics, Computer Language, Network Language, Realms of the Cyber world, A Brief History of the Internet, Recognizing and Defining Computer Crime, Contemporary Crimes, Computers as Targets, Contaminants and Destruction of Data, Indian IT ACT 2000

Module V:

Cyber Crime Investigation: Firewalls and Packet Filters, password Cracking, Key loggers and Spyware, Virus and Warms, Trojan and backdoors, Steganography, DOS and DDOS attack, SQL injection, Buffer Overflow, Attack on Wireless Networks

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended:

1. Mike Shema, Anti-Hacker Tool Kit (Indian Edition), Publication Mc Graw Hill.
2. Nina Godbole and Sunit Belpure, Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley Publication

Course Title	**Deep learning and Its Applications**
Course Code	**SDS21064**
Credit	**4**
Contact Hours (L-T-P)	**3-1-0**
Course Type	**Theory**

Course Objectives:

The objective of the course is to equip students with a comprehensive understanding of deep learning techniques and their practical applications across various fields.

Course Outcomes:

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

CO1. Understanding Fundamentals of Deep Learning
CO2. Understand Neural Network Architectures
CO3. Training Deep Learning Models
CO4. Implementing Deep Learning Frameworks

Course Description:

The course offers a comprehensive exploration of deep learning techniques and their transformative impact across various domains. Designed for students with a foundational understanding of machine learning, this course delves into the architectures, algorithms, and tools that drive deep learning innovations. This course aims to equip students with both theoretical knowledge and practical skills, preparing them for careers in data science, artificial intelligence, and related fields. By the end of the course, participants will have a solid foundation in deep learning and its applications, ready to tackle complex challenges in various industries.

Course Content:

Module I:

Neural Networks: Basic concepts of artificial neurons, single and multi-layer perceptrons, perceptron learning algorithm, its convergence proof, different activation functions, softmax cross entropy loss function.

Convolutional Neural Networks: Basic concepts of Convolutional Neural Networks starting from filtering, Convolution and pooling operation and arithmetic of these.

ConvNet Architectures: Discussions on famous Convnet architectures - AlexNet, ZFNet, VGG, C3D, GoogLeNet, ResNet, MobileNet-v1.

Regularization, Batchnorm: Discussion on regularization, Dropout, Batchnorm, momentum, RMS prop, Adam’s optimization algorithm, Learning rate decay, etc.

Module II:

Detection, Segmentation: Discussion on detection, segmentation problem definition, challenges, Evaluation, Datasets and Localization by regression, Discussion on detection as classification, region proposals, RCNN architectures.

Recurrent Neural Networks: Discussion on Recurrent Neural Networks (RNNs), Long-Short Term Memory (LSTM) architectures, and basics of word embedding

Module III:

Vision and Language: Discussion on different tasks involving Vision and Language e.g., Image and video captioning along with the use of attention and broad discussion about application areas.

Explainability and Bias: Discussion on explainability and bias in Deep Learning system. The need for explanation, introspection vs justification, activation maximization and activation map-based explanation generation, Black-box explanation generation, etc., Bias in AI and in image captioning tasks

Module IV:

Implantation (through mini project) of deep learning concepts: Complete a Deep Learning solution to a problem, starting from problem formulation, appropriate algorithm selection and implementation, and empirical study into the effectiveness of the solution

Evaluation:

Mode of Evaluation	Theory	
Weightage	Comprehensive and Continuous Assessment	End Semester Examination
	50%	50%

Books Recommended and web resources:

1. I Goodfellow, Y Bengio, and A Courville, Deep Learning, 1st Edition, [http://www.deeplearningbook.org/]
2. Juergen Schmidhuber, Deep Learning in Neural Networks: An Overview. 2014, [https://arxiv.org/abs/1404.7828]
3. http://neuralnetworksanddeeplearning.com/chap4.html
4. https://www.utdallas.edu/~herve/abdi-awPCA2010.pdf
5. https://www.cs.princeton.edu/picasso/mats/PCA-Tutorial-Intuition_jp.pdf
6. http://www-users.math.umn.edu/~lerman/math5467/svd.pdf

7. http://www.cimat.mx/~alram/met_num/clases/Abdi-SVD2007-pretty.pdf
8. https://adeshpande3.github.io/adeshpande3.github.io/The-9-Deep-Learning-Papers-You-Need-To-Know-About.html

Course Title	**Project/Dissertation & Viva-voce**
Course Code	**SDS25068**
Credit	**12**
Contact Hours (L-T-P)	
Course Type	**Project**

Course Objectives:

- To select a suitable dissertation proposal.
- To display evidence of understanding the requirements of focusing research ideas.
- To exhibit facts of understanding the requirements of dissertation writing.

Course Outcomes:

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

CO1: Identify key research opportunities in the area of project work

CO2: Show knowledge and potential degree of report writing and communicate easily to the viewer and readers.

CO3: Assess the learning towards industry readiness

Course Description:

This module will be provided with guidance and support throughout the preparation of report. From discussing initial ideas of dissertation through the process of actually writing the document, this module will be provided with the information and support required from both the teaching staff and allocated dissertation supervisor.

Evaluation:

Mode of Evaluation	Presentation, Viva, and Report
Weightage	End Semester Examination
	100%

CO-PO Correlation Matrix for the Programme
M.Sc. Tech (Statistics and Data Science)

Course Code	Course Name	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
SDS21096	Probability Theory and Distributions	CO1	3	1	1	-	-	-	-	-	-	-	-	3	2	-	-	-
		CO2	3	2	1	-	-	-	-	-	-	-	-	3	2	-	-	3
		CO3	3	2	1	3	2	-	-	-	-	-	-	3	3	2	2	3
		CO4	2	1	1	3	-	-	-	-	2	-	-	3	3	-	3	3
			2.75	**1.5**	**1**	**3**	**2**	-	-	-	**2**	-	-	**3**	**2.5**	**2**	**2.5**	**3**
MTH23071	Problem Solving and Applications	CO1	3	1	-	2	-	3	-	-	-	-	-	2	2	-	-	-
		CO2	2	2	-	3	-	3	-	-	-	-	-	2	2	-	-	2
		CO3	3	2	-	3	-	3	-	-	-	-	-	2	3	2	2	3
		CO4	2	1	-	2	-	3	-	-	-	-	-	2	2	1	-	2
			2.5	**1.5**	-	**2.5**	-	**3**	-	-	-	-	-	**2**	**2.25**	**1.5**	**2**	**2.33**
MTH21109	Linear Algebra	CO1	3	2	-	2	-	-	-	-	-	-	-	-	2	-	-	-
		CO2	3	2	-	3	2	-	-	-	-	-	-	-	3	-	-	3
		CO3	2	1	-	2	-	-	-	-	-	-	-	-	2	-	-	2
		CO4	3	2	-	3	2	-	-	-	-	-	-	-	3	-	-	3
		CO5	2	1	-	2	-	-	-	-	-	-	-	-	2	-	-	2
			2.6	**1.6**	**-**	**2.4**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2.4**	**-**	**-**	**2.5**
SDS21049	Applied Statistics I	CO1	3	2	3	2	-	3	3	-	-	-	-	3	2	-	-	-
		CO2	3	2	3	3	2	3	3	-	-	-	-	3	3	-	-	3
		CO3	2	1	3	2	-	3	3	-	1	-	-	3	2	-	-	2
		CO4	3	2	3	3	-	3	3	-	1	-	-	3	3	-	-	3
		CO5	2	1	3	2	-	3	3	2	-	-	-	3	2	1	-	2
			2.6	**1.6**	**3**	**2.4**	**2**	**3**	**3**	**2**	**1**	-	-	**3**	**2.4**	**1**	-	**2.5**
SDS22093	Applied Statistics I Lab	CO1	3	2	3	3	2	-	-	-	-	-	-	3	2	-	-	3
		CO2	2	1	3	2	-	-	-	-	-	-	-	3	2	-	-	2
		CO3	3	2	3	3	-	-	-	-	-	-	-	3	3	-	-	3
		CO4	2	1	3	2	-	1	-	-	-	-	-	3	2	1	-	2
			2.5	**1.5**	**3**	**2.5**	**2**	**1**	-	-	-	-	-	**3**	**2.25**	**1**	-	**2.5**

MTH21110	**Calculus and Optimization**	**CO1**	3	2	-	2	-	-	-	-	-	-	-	1	2	-	-	-
		CO2	3	2	-	3	-	-	-	-	-	-	-	1	3	-	-	-
		CO3	2	1	-	3	2	-	-	-	-	-	-	1	2	1	-	2
		CO4	2	1	-	2	-	-	-	-	-	-	-	1	2	-	-	2
			2.5	**1.5**	-	**2.5**	**2**	-	-	-	-	-	-	**1**	**2.25**	**1**	-	**2**
SDS23097	**Data Analysis and Visualization with Python**	**CO1**	3	2	2	2	3	3	-	-	-	2	-	2	3	-	-	2
		CO2	3	2	2	2	-	-	2	-	-	-	-	2	2	-	-	3
		CO3	3	2	2	3	2	-	-	-	1	-	-	2	3	1	-	3
		CO4	2	2	2	3	2	-	-	-	-	-	-	2	2	-	-	3
			2.75	**2**	**2**	**2.5**	**2.33**	**3**	**2**	-	**1**	**2**	-	**2**	**2.5**	**1**	-	**2.75**
SDS21098	**Sampling Theory**	**CO1**	3	2	1	2	2	-	-	1	1	1	1	-	3	-	-	2
		CO2	3	2	1	2	2	-	-	1	1	2	-	-	2	-	-	2
		CO3	3	3	3	3	-	-	-	1	1	1	-	-	2	-	-	3
		CO4	3	2	1	3	-	-	-	1	1	1	-	-	2	-	-	2
			3	**2.25**	**1.5**	**2.5**	**2**	-	-	**1**	**1**	**1.25**	**1**	-	**2.25**	-	-	**2.25**
SDS21058	**Machine Learning and Applications**	**CO1**	3	2	1	2	3	1	-	2	2	2	2	2	3	3	2	3
		CO2	3	3	2	3	3	1	-	2	3	3	2	2	3	3	2	3
		CO3	2	2	3	2	2	1	-	2	2	2	2	2	3	2	1	2
		CO4	2	2	1	3	3	1	-	2	3	2	2	2	3	3	2	3
		CO5	1	2	1	2	3	1	-	2	2	2	2	2	2	2	1	2
			2.2	**2.2**	**1.6**	**2.4**	**2.8**	**1**	**-**	**2**	**2.4**	**2.2**	**2**	**2**	**2.8**	**2.6**	**1.6**	**2.6**
SDS22059	**Machine Learning and Applications Lab**	**CO1**	3	2	-	3	3	3	-	-	-	2	-	2	3	-	3	3
		CO2	3	2	-	3	3	3	-	-	-	2	-	2	3	-	3	3
		CO3	3	2	-	3	3	3	-	-	-	2	-	2	3	2	3	3
		CO4	3	2	-	3	3	3	-	-	-	2	-	2	3	-	3	3
			3	**2**	-	**3**	**3**	**3**	-	-	-	**2**	-	**2**	**3**	**2**	**3**	**3**

SDS21050	**Statistical Inference**	**CO1**	3	2	-	2	-	3	-	-	-	-	-	-	3	-	-	2
		CO2	3	3	-	2	-	3	-	-	-	-	-	1	3	-	-	2
		CO3	3	3	-	3	-	3	-	-	-	2	-	1	3	-	3	3
		CO4	3	3	-	3	-	3	-	-	-	2	-	-	3	-	3	3
			3	**2.75**	-	**2.5**	-	**3**	-	-	-	**2**	-	**1**	**3**	-	**3**	**2.5**
SDS21052	**Applied Statistics II**	**CO1**	3	2	-	2	-	-	2	-	-	-	-	-	2	-	-	2
		CO2	3	3	-	3	-	-	3	-	-	-	-	-	3	-	-	2
		CO3	3	3	-	3	-	-	3	-	-	2	-	-	3	-	3	3
		CO4	3	3	-	3	-	-	3	-	-	-	-	-	3	-	3	3
			3	**2.75**	-	**2.75**	-	-	**2.75**	-	-	**2**	-	-	**2.75**	-	**3**	**2.5**
SDS22094	**Applied Statistics II Lab**	**CO1**	3	2	-	3	2	-	-	-	-	-	-	2	2	-	-	2
		CO2	3	3	-	3	3	-	-	-	-	-	-	2	3	-	-	2
		CO3	3	3	-	3	3	-	-	-	-	-	-	2	3	-	3	3
		CO4	3	3	-	3	3	-	-	-	-	-	-	2	3	-	3	3
			3	**2.75**	-	**3**	**2.75**	-	-	-	-	-	-	**2**	**2.75**	-	**3**	**2.5**
CSE21741	**Data Structures and Algorithm design**	**CO1**	3	2	-	2	3	-	-	-	-	-	-	-	2	-	-	2
		CO2	3	2	-	2	2	-	-	-	-	-	-	-	2	-	-	2
		CO3	2	1	-	3	-	-	-	-	-	-	-	-	2	-	-	-
		CO4	3	2	-	3	3	-	-	-	-	-	-	-	3	-	-	2
		CO5	3	2	-	3	3	-	-	-	-	-	-	-	3	-	3	3
		CO6	3	2	-	3	3	-	-	-	-	-	-	-	3	-	3	3
			2.83	**1.83**	-	**2.67**	**2.8**	-	-	-	-	-	-	-	**2.5**	-	**3**	**2.4**
CSE22742	**Data Structures and Algorithm design Lab**	**CO1**	3	2	-	3	3	-	-	-	-	-	-	-	2	-	-	2
		CO2	3	2	-	2	3	-	-	-	-	-	-	-	2	-	-	2
		CO3	3	2	-	3	3	-	-	-	-	-	-	-	3	-	-	3
		CO4	3	2	-	3	3	-	-	-	-	-	-	-	3	-	3	3
			3	**2**	-	**2.75**	**3**	-	-	-	-	-	-	-	**2.5**	-	**3**	**2.5**

SDS23099	**Statistical Techniques in Data Mining**	**CO1**	3	2	-	2	2	-	-	-	1	-	-	-	2	-	-	2
		CO2	3	2	-	3	3	-	-	-	1	-	-	-	3	-	-	3
		CO3	2	2	2	2	2	2	2	-	-	-	-	-	2	2	2	2
		CO4	3	2	-	3	3	-	-	-	1	-	-	-	3	-	-	3
		CO5	3	3	2	3	3	2	2	-	-	-	-	-	3	2	3	3
			2.8	**2.2**	**2**	**2.6**	**2.6**	**2**	**2**	-	**1**	-	-	-	**2.6**	**2**	**2.5**	**2.6**
SDS21051	**Mathematical and Stochastic Modelling**	**CO1**	3	2	2	2	-	-	-	-	-	-	-	3	2	-	-	2
		CO2	3	2	2	3	2	-	1	-	-	-	-	3	3	-	-	2
		CO3	3	2	2	3	2	-	1	-	-	-	-	3	2	-	-	2
		CO4	3	3	2	3	3	-	1	-	-	-	-	3	3	-	-	3
		CO5	3	2	2	3	2	2	-	-	-	-	-	3	3	2	3	3
			3	**2.2**	**2**	**2.8**	**2.25**	**2**	**1**	-	-	-	-	**3**	**2.6**	**2**	**3**	**2.4**
MTH23111	**Numerical Techniques**	**CO1**	3	2	-	-	2	-	-	-	-	-	-	-	3	-	-	2
		CO2	3	3	-	2	3	-	-	-	-	-	-	-	3	-	-	3
		CO3	3	2	-	3	2	-	-	-	-	-	-	-	2	-	-	2
		CO4	3	3	-	3	2	-	-	-	-	-	-	-	3	2	-	3
		CO5	3	2	-	3	3	2	-	-	-	-	-	-	3	2	3	3
			3	**2.4**	-	**2.75**	**2.4**	**2**	-	-	-	-	-	-	**2.8**	**2**	**3**	**2.6**
CSE21745	**Database Management System with SQL**	**CO1**	3	2	3	-	-	-	-	-	-	-	1	2	-	-	-	-
		CO2	3	2	3	2	-	-	-	-	2	-	2	2	-	-	-	-
		CO3	3	3	3	3	2	2	-	-	3	-	2	2	-	-	-	3
		CO4	3	3	3	3	2	2	-	-	3	1	2	2	3	-	-	3
		CO5	3	2	3	2	-	-	-	-	2	-	2	2	-	-	-	-
			3	**2.4**	**3**	**2.5**	**2**	**2**	-	-	**2.5**	**1**	**1.8**	**2**	**3**	-	-	**3**
CSE22746	**Database Management System with SQL Lab**	**CO1**	3	2	3	3	2	2	-	-	3	-	2	2	-	-	-	-
		CO2	3	2	3	3	2	2	-	-	3	-	2	2	-	-	-	3
		CO3	3	3	3	2	-	-	-	-	2	-	2	2	3	-	-	3
			3	**2.33**	**3**	**2.5**	**2**	**2**	-	-	**2.5**	**-**	**1.96**	**2**	**3**	-	-	**3**

SDS24060	**Summer Internship (Industry/Institute visit)**	**CO1**	2	2	2	3	-	1	1	1	2	2	1	3	-	3	-	3
		CO2	2	3	2	-	3	1	1	1	2	2	1	3	-	3	-	3
		CO3	2	2	2	-	-	1	1	1	2	2	1	3	-	3	-	-
			2	**2.33**	**2**	**3**	**3**	**1**	**1**	**1**	**2**	**2**	**1**	**3**	**-**	**3**	**-**	**3**
SDS24061	**Minor project**	**CO1**	2	3	-	3	-	-	-	-	-	-	-	3	-	3	-	2
		CO2	3	2	-	3	-	-	-	-	-	-	-	3	-	3	-	3
		CO3	-	-	-	2	3	-	-	-	1	-	-	3	-	2	-	3
		CO4	2	2	3	2	-	-	-	-	-	2	-	3	2	3	2	3
			2.33	**2.33**	**3**	**2.5**	**3**	**-**	**-**	**-**	**1**	**2**	**-**	**3**	**2**	**2.75**	**2**	**2.75**
CSE21751	**Artificial Intelligence and Applications**	**CO1**	3	2	-	2	3	-	-	-	-	-	-	2	-	3	-	-
		CO2	2	2	-	3	3	-	-	-	-	-	-	2	-	3	2	-
		CO3	2	3	-	2	-	-	-	-	-	-	-	2	-	2	-	-
		CO4	3	2	-	3	3	-	-	-	-	-	-	2	-	3	2	3
		CO5	3	3	-	2	3	-	-	-	-	-	-	3	-	3	2	3
		CO6	2	2	-	2	3	2	-	-	-	-	-	2	-	3	-	2
			2.5	**2.33**	**-**	**2.33**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**2.17**	**-**	**2.83**	**2**	**2.67**
SDS21043	**Stochastic Process**	**CO1**	3	2	-	2	3	-	-	-	-	-	-	2	-	3	-	-
		CO2	2	3	-	3	2	-	-	-	-	-	-	3	-	3	2	-
		CO3	3	2	-	3	3	-	-	-	-	-	-	2	-	3	2	3
		CO4	2	3	-	3	2	-	-	-	-	-	-	2	-	3	2	3
			2.5	**2.5**	**-**	**2.75**	**2.5**	**-**	**-**	**-**	**-**	**-**	**-**	**2.25**	**-**	**3**	**2**	**3**
SDS25068	**Project/Dissertation & Viva-voce**	**CO1**	3	2	3	2	-	-	-	-	-	-	-	-	2	3	-	-
		CO2	2	2	3	2	-	-	-	3	-	3	-	3	2	-	3	-
		CO3	2	2	-	3	-	-	-	-	2	-	3	3	3	2	3	3
			2.33	**2**	**3**	**2.33**	**-**	**-**	**-**	**3**	**2**	**3**	**3**	**3**	**2.33**	**2.5**	**3**	**3**

SDS21100	**Survival Analysis**	**CO1**	3	2	-	2	3	-	-	1	2	2	1	-	3	2	1	2
		CO2	3	2	1	2	3	-	-	1	2	2	2	-	3	2	1	3
		CO3	2	2	2	3	2	-	-	1	2	2	-	-	2	1	1	2
		CO4	1	1	1	3	2	-	-	1	1	1	-	-	2	2	1	2
			2.25	**1.75**	**1.33**	**2.5**	**2.5**	**-**	**-**	**1**	**1.75**	**1.75**	**1.5**	**-**	**2.5**	**1.75**	**1**	**2.25**
SDS21101	**Statistical Quality Control**	**CO1**	3	2	-	2	3	-	-	1	2	2	1	-	3	2	1	2
		CO2	3	2	1	2	3	1	-	1	3	2	2	-	3	2	1	3
		CO3	2	2	2	3	2	1	-	1	2	2	1	-	2	1	1	2
		CO4	1	1	1	3	2	1	-	1	1	1	-	-	2	2	1	2
			2.25	**1.75**	**1.33**	**2.5**	**2.5**	**1**	**-**	**1**	**2**	**1.75**	**1.33**	**-**	**2.5**	**1.75**	**1**	**2.25**
CSE21749	**Cryptography and Network Security**	**CO1**	2	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
		CO2	3	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
		CO3	3	2	-	3	-	-	-	-	-	2	-	-	-	-	-	-
		CO4	2	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-
		CO5	3	2	-	3	-	2	-	2	-	-	-	-	-	2	-	3
			2.6	**2.2**	-	**2.6**	-	**2**	-	**2**	-	**2**	-	-	-	**2**	-	**3**
CSE21752	**Cloud Computing**	**CO1**	2	1	-	2	3	-	-	1	2	2	1	-	2	2	1	2
		CO2	2	2	1	2	3	1	-	1	2	2	2	-	3	2	1	3
		CO3	1	2	2	3	2	-	-	1	1	1	-	-	2	1	1	2
		CO4	1	1	1	2	2	1	-	1	1	1	-	-	2	2	1	2
			1.5	**1.5**	**1.33**	**2.25**	**2.5**	**1**	**-**	**1**	**1.5**	**1.5**	**1.5**	**-**	**2.25**	**1.75**	**1**	**2.25**
SDS21102	**Clinical Trials and Biostatistics**	**CO1**	3	2	1	2	2	2	1	-	-	2	1	-	2	3	2	1
		CO2	3	3	2	3	2	2	2	-	-	1	1	-	3	2	2	2
		CO3	2	2	3	2	1	2	1	-	1	1	-	-	2	2	1	2
		CO4	2	2	1	3	3	1	2	1	1	-	-	-	2	2	2	2
			2.5	**2.25**	**1.75**	**2.5**	**2**	**1.75**	**1.5**	**1**	**1**	**1.33**	**1**	**-**	**2.25**	**2.25**	**1.75**	**1.75**

SDS21103	**Demography**	**CO1**	3	2	1	2	1	2	1	-	-	2	1	-	2	2	1	1
		CO2	3	3	2	3	1	2	2	-	-	1	1	-	3	2	1	2
		CO3	2	2	3	2	2	2	1	-	1	1	-	-	2	2	1	2
		CO4	2	2	1	3	2	1	2	1	1	-	-	-	2	2	1	1
			2.5	**2.25**	**1.75**	**2.5**	**1.5**	**1.75**	**1.5**	**1**	**1**	**1.33**	**1**	-	**2.25**	**2**	**1**	**1.5**
SDS21062	**Big Data Analytics**	**CO1**	2	1	-	2	3	-	-	1	2	2	1	-	3	3	1	2
		CO2	3	2	1	2	3	1	-	1	2	2	2	-	3	3	1	3
		CO3	1	2	2	3	2	1	-	1	1	1	-	-	2	1	1	2
		CO4	1	1	1	3	2	1	-	1	1	1	-	-	2	2	1	2
		CO5	1	1	-	2	3	1	-	1	1	2	-	-	2	2	1	2
		CO6	2	2	-	-	2	-	-	-	-	-	-	-	-	2	-	2
			1.67	**1.5**	**1.33**	**2.4**	**2.5**	**1**	-	**1**	**1.4**	**1.6**	**1.5**	-	**2.4**	**2.17**	**1**	**2.17**
CSE21750	**Cyber Security for Data Science**	**CO1**	3	2	-	-	-	2	-	2	2	-	-	-	-	2	-	-
		CO2	3	2	-	2	-	2	-	2	-	-	-	-	-	3	1	-
		CO3	3	2	-	2	-	2	-	2	-	-	-	-	-	3	-	2
		CO4	2	1	-	2	-	2	-	3	-	2	-	2	-	2	1	-
			2.75	**1.75**	-	**2**	-	**2**	-	**2.25**	**2**	**2**	-	**2**	-	**2.5**	**1**	**2**
SDS21064	**Deep Learning and Its Applications**	**CO1**	2	1	-	2	3	-	-	1	2	2	1	-	3	3	1	2
		CO2	3	2	1	2	3	1	-	1	2	2	2	-	3	3	1	3
		CO3	1	2	2	3	2	-	-	1	1	1	-	-	2	1	1	2
		CO4	1	1	1	3	2	1	-	1	1	1	-	-	2	2	1	2
			1.75	**1.5**	**1.33**	**2.5**	**2.5**	**1**	-	**1**	**1.5**	**1.5**	**1.5**	-	**2.5**	**2.25**	**1**	**2.25**