File Ref.No.Ac.A3/Faculty of Science/2023 (PART-I)

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Science - Revised course structure and syllabi of M.Sc. Statistics and M.Tech Data Science and Analytics Programme effective from 2024 admission onwards - Resolution of the Academic Council - Communicated - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/3583/2024 Dated,KOCHI-22,22.08.2024

Read:-Item No. I (g)(6) of the minutes of the meeting of the Academic Council held on 30.04.2024

ORDER

The Academic Council considered along with the recommendations of its standing committee, the Minutes of the Faculty of Science held on 08.04.2024 and resolved to approve the revised course structure and syllabi for the following programmes:

i. M.Sc.Statistics with effect from 2024 admissions (Appendix I)
ii. M.Tech Data Science and Analytics with effect from 2024 admissions (Appendix II)

Orders are, therefore, issued accordingly.

Dr. V. Sivanandan Achari *
Registrar

To:

1. The Dean, Faculty of Science
2. Chairmen, BoS under Faculty of Science
3. The Head, Department of Statistics
4. All AR/DR Examination wing - with a request to forward to concerned sections
5. The Director,IQAC/ DoA
6. CIRM/Conference Sections
7. PS To VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

M.TECH. IN DATA SCIENCE AND ANALYTICS

A program offered by

The Department of Statistics

Under the Faculty of Science

DEPARTMENT OF STATISTICS
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
Kochi 682 022

M.TECH. IN DATA SCIENCE AND ANALYTICS

Under Faculty of Science

Objectives of the Programme:

Data scientists and professionals with data analytic skill are in great demand. The objective of this programme is to train graduates from different disciplines to become Data Scientists who can handle data analytics efficiently. Data Analytics is the application of structured statistical techniques on collected data in order to detect the underlying pattern as well as make predictions. The programme aims at learning Data Science via a comprehensive course curriculum covering Statistical tools and techniques, key programming languages such as R, Python, Machine learning algorithms and more.

Students are trained on the simultaneous application of statistics, computer programming, operations research and optimization techniques to analyze data patterns which help in effective decision making. The course also covers a broad spectrum of analytics and application knowledge areas required for overall professional development. The first two semesters are devoted to classroom teaching and laboratory practicals. In the third and fourth semesters, the candidates will be focusing on advanced level elective courses and they will be sent to undertake project work in industries of their choice.

Program Outcomes:

On successful completion of 'M.Tech in Data Science and Analytics' program the students will be able to

1. Become Data science professionals.
2. Acquire knowledge in modern statistical and technology tools required for handling data analytics in a wide variety of application domains.
3. Critically investigate the prevailing complex problem scenarios in industries and arrive at optimal solutions by applying the acquired theoretical and practical knowledge.
4. Handle advanced level machine learning algorithms to solve complex problems and master the relevant statistical packages for interpreting the results.
5. Undertake teaching/research careers in Data Science/Statistics and allied areas and be involved in the process of knowledge discovery and effective communication of the same.

Eligibility Criteria:

Pass in M.Sc (Statistics/Mathematics/Computer Science)/MCA or equivalent to any of this approved by this University with at least 60% marks or CGPA 6.5/10 or equivalent grade

OR

Pass in B.Tech in any branch with atleast 60% marks or CGPA 6.5/10 or equivalent grade

Duration of the Programme	:	Four Semesters
Examination	:	Credit and Semester
Intake	:	18
Mode of admission	:	Based on Admission Test

COURSE STRUCTURE (with effect from 2024 ADMISSION onwards)

SEMESTER I

Sl. No.	Course Code	Name of the Paper	Core/ Elective	Credits	CE Marks	ES Marks	Total Marks
1	24-478-0101	Mathematical Methods for Data Science	C	3	50	50	100
2	24-478-0102	Probability and Statistical Inference	C	4	50	50	100
3	24-478-0103	Data Structures and Algorithms	C	3	50	50	100
4	24-478-0104	Python Programming-Practical I	C	2	50	50	100
5		Elective I	E	3	50	50	100
6		Elective II	E	3	50	50	100

Minimum Credits: 18 (Core: 12, Elective: 6)

List of Electives for Semester I

Sl. No.	Course Code	Name of the Paper
1	24-478-0105	Systems and Decision Analytics
2	24-478-0106	Data Warehousing and Data Mining
3	24-478-0107	Data Analysis and Visualization using Python
4	24-478-0108	Operations and Supply Chain Management
5	24-478-0109	System Reliability and Risk Analysis
6	24-478-0110	Computational Thinking

SEMESTER II

Sl. No	Course Code	Name of the Paper	Core/ Elective	Credits	CE Marks	ES Marks	Total Marks
1	24-478-0201	Simulation Modelling and Analysis	C	3	50	50	100
2	24-478-0202	Machine Learning	C	4	50	50	100
3	24-478-0203	Multivariate Analysis and Statistical Techniques for Data Mining	C	3	50	50	100
4	24-478-0204	R/R-Studio Programming-Practical II	C	2	50	50	100
5		Elective III	E	3	-	100	100
6		Elective IV	E	3	50	50	100

Minimum Credits: 18 (Core: 12, Elective: 6)

Elective -III for Semester II

A MOOC course, from SWAYAM/NPTEL/Moodle/Others, will be opted for by students with the approval of the Department Council and will have the end semester evaluation ONLY, for 100 marks.

List of Courses for Electives IV

Sl. No.	Course Code	Name of the Paper
1	24-478-0205	Optimization Techniques
2	24-478-0206	Design of Experiments (Integrated with R)
3	24-478-0207	Artificial Intelligence and Deep Learning
4	24-478-0208	Natural Language Processing
5	24-478-0209	Financial Risk Analytics and Management
6	24-478-0210	Marketing and HR Analytics
7	24-478-0211	Bioinformatics
8	24-478-0212	Big Data Technology

SEMESTER III

Sl. No.	Course Code	Name of the Paper	Core/ Elective	Credits	CE Marks	ES Marks	Total Marks
1	24-478-0301	Project on Data Analytics in Industry	C	15	150	150	300
2		Elective V	E	3	50	50	100

Minimum Credits: 18 (Core: 15, Elective: 3)

List of Electives for Semester III

Sl. No.	Course Code	Name of the Paper
1	24-478-0302	Business Analytics
2	24-478-0303	Statistical Forecasting Methods
3	24-478-0304	Quality Management and Six Sigma
4	24-478-0305	Applied Longitudinal Data Analysis
5	24-478-0306	Lifetime Studies in Data Science (Integrated with R).
6	24-478-0307	Bayesian Computing &Analysis

SEMESTER IV

Sl. No	Course code	Name of the Paper	Core/ Elective	Credits	CE Marks	ES Marks	Total Marks
1	24-478-0401	Project Dissertation Evaluation and Viva	C	18	200	200	400

Minimum Credits: 18 (Core: 18)

*Additional electives from Industry/Institutions can be offered during third and fourth semesters with the approval of Department Council and University.

DETAILED SYLLABUS

24-478-0101: MATHEMATICAL METHODS FOR DATA SCIENCE

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the applications of vectors and matrices in data science	Understand
2.	Represent the problems in the form of a system of linear equations and how to construct machine learning algorithm	Evaluate
3.	Identify the applications of calculus in optimization methods such as least squares, machine learning, etc.	Apply
4.	Formulate an optimization problem	Apply
5.	Prepare algorithm to solve optimization problems	Evaluate

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2		2	2
CO2	3		2	3	3
CO3		2		2	
CO4	3	2		2	
CO5	1	2	2		3

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Basic properties of matrix and vectors: linear transformation, rank, determinant, inner and outer products, matrix multiplication rule and various algorithms, matrix inverse.
Special matrices: square matrix, identity matrix, triangular matrix, idea about sparse and dense matrix, unit vectors, symmetric matrix, Hermitian, skew-Hermitian and unitary matrices, Generalized inverses.

Module 2:

Matrix factorization concept/LU decomposition, Gaussian/Gauss-Jordan elimination, solving Ax=b linear system of equation,vector space,basis, span, orthogonality, orthonormality, linear least square, Eigen values, eigenvectors, diagonalization, singular value decomposition, Quadratic forms ,Spectral decomposition.

Module 3:

Functions of a single variable, limit, continuity, differentiability, Mean value theorems, Product and chain rule, Taylor's series, infinite series summation/integration. Fundamental and mean value theorems of integral calculus, evaluation of definite and improper integrals, Beta and gamma functions, Functions of multiple variables, limit, continuity, partial derivatives, Basics of ordinary and partial differential equations, numerical integration.

Module 4:

Sets, subsets, power sets, counting functions, combinatorics, countability, Basics of optimization techniques: problem formulation, Maxima, minima, convex function, global solution, Linear programming, simplex algorithm, Integer programming, Constraint programming, Randomized optimization techniques: hill climbing, simulated annealing, genetic algorithms.

Reference Books:

1. Gilbert Strang (2014) .Linear Algebra and Its Applications, 4th Edition, Cengage Learning India Pvt. Ltd.

2. Marc Peter Deisenroth, A.Aldo Faisal and Cheng Soon Ong (2020). Mathematics for Machine Learning .Cambridge University Press.

3. AvrimBlum, John Hopcroft, Ravindran Kannan: Foundations of Data Science, 2018 https://www.cs.cornell.edu/jeh/book.pdf

24-478-0102: PROBABILITY AND STATISTICAL INFERENCE

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Describe sample space and events	Understand
2.	Understand axiomatic probability and know how to model real-world problems using it	Understand
3.	Understand Discrete and Continuous Random Variables, their Distributions, their properties, moments and correlations	Understand
4.	Understand the limiting behavior of large amounts of data by limit theorems	Understand
5.	Demonstrate conceptual understanding of sampling distributions and the central limit theorem	Apply
6.	Estimate parameters of distributions using maximum Likelihood and Other estimation techniques	Evaluate
7.	Assess the properties of estimators	Evaluate
8.	Construct confidence intervals for point estimates	Evaluate
9.	Test hypotheses about different parameters of distributions of populations using samples of data	Analysis

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1					1
CO2					1
CO3	2				
CO4	2				2
CO5		3			
CO6	1	2			
CO7					
CO8					2
CO9	2	2			2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Sample space, Probability axioms, Probability on finite sample spaces, conditional probability and Bayes theorem, independent of events, random variables, probability distribution of a random variable, discrete and continuous random variables, functions of random variables, moments of a distribution function, generating functions. Discrete distributions: Binomial distribution,negative binomial distribution, geometric distribution, hypergeometric distribution, negative hypergeometric distribution, Poisson distribution, Continuous distribution: Uniform distribution, exponential distribution, gamma distribution, beta distribution, Normal distribution

Module 2:

Mode of convergence, weak law of large numbers, strong law of large numbers, central limit theorems, random sampling, sample characteristics and their distributions, Chi-square, t-and F-distributions, large sample theory.

Module 3:

Concept of sufficiency, minimal sufficiency, Neyman factorization criterion, Fisher information, exponential families, Maximum likelihood estimators, method of moment estimators, percentile estimators, least squares estimators, minimum mean squares estimators, uniformly minimum variance unbiased estimators, Rao-Blackwell theorem, Cramer-Rao lower bound, different examples.

Module 4:

Statistical Hypotheses-simple and composite, statistical tests, critical regions, Type-I and Type-II errors, size and power of a test, Neyman Pearson lemma and its different applications. Most powerful test, uniformly most powerful test, unbiased test and uniformly most unbiased test, Likelihood ratio test, Interval estimation, confidence intervals, construction of confidence intervals, shortest expected length confidence interval, most accurate one-side d confidence interval and its relation to UMP test.

Reference Books:

1. V.K. Rohatgi and A.K .Md. Saleh (2001) An introduction to probability and Statistics, Wiley India.
2. George Casella and Roger L Berger (2002) Statistical Inference, Thomson Learning.
3. Efron B. and Hastie T (2017). Computer Age Statistical Inference-Algorithms, Evidence and Data Science, Cambridge University Press.
4. Avrim Blum, John Hopcroft, Ravindran Kannan, Foundations of Data Science, 2018 https://www.cs.cornell.edu/jeh/book.pdf

24-478-0103: DATA STRUCTURES AND ALGORITHMS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Basic ability to analyze algorithms and to determine algorithm correctness	Analyze
2.	Choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a Specific problem	Evaluate
3.	Understand the necessary mathematical abstraction to solve problems	Analyze
4.	Comprehend and select algorithm design approaches in a problem specific manner	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1				2	
CO2			2		
CO3	2		2		
CO4			1		1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to Basic Data Structures: Importance and need of good data structures and algorithms, Linked lists, Queues, Heaps, Hash tables, Binary search trees.

Module 2:

Advanced Data Structures: Red-Black Trees, B-trees, Fibonacci heaps, Data Structures for Disjoint Sets. Design Strategies: Divide-and-conquer, Dynamic Programming, Greedy Method.

Module 3:

Internal and External Sorting algorithms: Linear Search, Binary Search, Bubble Sort, Insertion Sort, Shell Sort, Quick Sort, Heap Sort, Merge Sort, Counting Sort, Radix Sort. Advanced String-Matching Algorithms: The naive string-matching algorithm, Rabin-Karp, String matching with finite automaton, Knuth-Morris-Pratt algorithm.

Module 4:

Graph Algorithms: Elementary graph algorithms, Minimum spanning trees, shortest path algorithms: single source and all pair, Max flow problem and its solutions, Graph coloring problem and its solutions, Bio-inspired algorithms: Swarm Intelligence, Ant Colony Optimization, and recent trends in data structures.

Reference Books:

1. Cormen T.H., Leiserson, C.E., Rivest R.L. and Stein C (2010). Introduction to Algorithms 3rded. MIT Press.
2. S.Sridhar. Design and Analysis of Algorithms. Oxford University Press India, 2014
3. Aho A.V., Hopcroft J.E and Ullman J.D. Data Structures and Algorithms. India: Pearson Education,2009
4. Horowitz E., Sahni S. and Rajasekaran S. Fundamentals of Computer Algorithms, Galgotia Publications, 2010.
5. Weiss M.A. Data Structures and Algorithm Analysis in C++, India: Pearson, Third Edition, 2014.
6. Horowitz, Sahni and Anderson-Freed, Fundamentals of Data Structures in C, Universities Prese, 2008

24-478-0104: PYTHON PROGRAMMING – PRACTICAL I

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Define python environment	Understand
2.	Explain python programming language	Evaluate
3.	Develop a scientific computing environment using python	Evaluate
4.	Identify the use of python software to meet the given Scientific objective	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		1			
CO2		3		3	3
CO3		3		3	3
CO4		1		1	3
CO5					

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction: The Process of Computational Problem Solving, Python Programming Language; Python Data Types: Expressions, Variables and Assignments, Strings, List, Objects and Classes, Python Standard Library, Imperative Programming: Python programs, Execution Control Structures, User-Defined functions, Python Variables and Assignments, Parameter Passing. Text Files: Strings, Formatted Output, Files, Errors and Exception Handling, Execution and Control Structures: if Statement, for Loop, Two Dimensional lists, while Loop, More Loop Patterns, Additional Iteration Control Statements, Containers and Randomness: Functions: Definition, Call, Arguments, Scope rules and Name resolution, Lambda functions Built-in data types for data collections: Lists, Tuple, set and dictionary: Basic Operations, Iteration, Indexing, Slicing and Matrices; Dictionaries: Basic dictionary operations Error Handling and debugging.

Module 2:

Python Modules: Python file handling: Import, Write/create files, Delete files; Scientific Programming with Python: 1. Numpy Basics – Creating array, indexing, slicing, data types, Copy and view, iteration, Split, search, sort, filter; 2. Pandas Basics: Introduction to Pandas and its data structures (Series, Data Frame), Reading and writing data with Pandas, Data cleaning and preprocessing with Panda, Checking Null values, remove duplicates, correlations, plotting, 3. Plotting with matplotlib and seaborn.

Reference Books:

1. McKinney W. (2013). Python for Data Analysis. India: O'Reilly Media, Incorporated.
2. Charles Dierbach. (2012). Introduction to computer science using Python a computational problem-solving focus, John-Wiley & Sons.
3. McKinney W. (2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython. United States: O'Reilly Media.
4. Perkovic L. (2011). Introduction to computing using python: An Application development focus. Wiley Publishing.
5. McKinney W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy and IPython. "O Reilly Media, Inc."

24-478-0105: SYSTEMS AND DECISION ANALYTICS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the basic concepts of systems and system thinking	Understand
2.	Apply diagrammatic aids to capture problem situation	Apply
3.	Identify elements for an optimization model	Evaluate
4.	Use the basics tools for system studies such as system dynamics and simulations	Apply
5.	Evaluate decision problems and perform utility or risk analysis	Evaluate
6.	Develop decisions aids for informed decisions using hard/soft OR methodology	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2		3		2
CO2		3			
CO3			2	2	
CO4	2			2	
CO5				1	
CO6		1			2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Overview of decision-making process; role of analytics in decision making; Systems thinking, efficiency and effectiveness, unplanned and counter intuitive outcomes, reductionist and cause-and-effect thinking, black boxes approach, hierarchy of systems, feedback loops, control of systems, mind maps, cognitive mapping, causal loop diagrams, influence diagrams and other system diagrams.

Module 2:

Soft systems thinking, Checkland's soft systems methodology; Hard OR paradigm, problem scoping and modelling phase, the implementation phase, code of ethics
Decision making over time: planning horizon, production planning problem.

Module 3:

Prescriptive Analytics: Linear Optimization: Identifying elements for an Optimization Model - Translating Model -Solving Linear Optimization Models -Graphical Interpretation of Linear Optimization - Solving Models with General Integer Variables; Simulation and system dynamics: the structure of simulation models, computer simulation packages, basics of system dynamics.

Module 4:

Decision Analysis - Formulating Problems - Strategies for Minimizing and Maximizing Objectives - Conflicting Goals - Strategies with Known Probabilities - Average Payoff and Expected Value - Decision Trees and Monte Carlo Simulation - Value of Information - Sample Information - Bayes's Rule - Utility - Multicriteria Decision Making - Analytic Hierarchy Process.

Reference Books:

1. H.G. Daellenbach and D.C. McNickle, Management Science, Decision Making Through Systems Thinking, Palgrave Macmillan, 2005
2. F.S.Hillier and J.Lieberman, Introduction to Operations Research, Tenth Edition, McGraw-Hill, New York, 2015

3. Law.A.M, Simulation Modeling and Analysis, Fifth edition, McGraw-Hill New York, 2015
4. J.R.Evans, Business Analytics, Pearson Education; Second edition, 2017.
5. K.C. James, Systems, Models and Decision Making, Amazon Publishing, 2023

24-478-0106: DATA WAREHOUSING AND DATA MINING

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the functionality of the various data mining and data warehousing components	Understand
2.	Examine the types of the data to be mined and apply pre-processing methods on raw data	Evaluate
3.	Expose various real-world data mining applications	Apply
4.	Apply the functionality of the various data warehousing components	Apply
5.	Develop an understanding of the data mining techniques and issues	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			3	3
CO2	2			3	3
CO3			3		
CO4	3				3
CO5	3				

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Data Warehouse: Introduction to Data Ware House, Differences between operational data base systems and data Ware House, Data Ware House characteristics, Data Ware House Architecture and its components, Extraction-Transformation Loading, Logical (Multidimensional), Data Modeling, Schema Design, star and snow-Flake Schema, Fact Constellation, Fact Table, Fully Addictive, Semi-Addictive, Non-Addictive Measures; Fact Less-Facts, Dimension Table characteristics; Fact-Less-Facts, Dimension Table characteristics; OLAP cube, OLAP Operations, OLAP Server Architecture-ROLAP, MOLAP and HOLAP.

Module 2:

Introduction to Data Mining: Introduction, What is Data Mining, Definition, KDD, Challenges, Data Mining Tasks, Data Pre-processing - Data Cleaning, Missing Data, Dimensionality Reduction, Feature Subset Selection, Discretization and Binaryzation, Data Transformation; Measures of similarity and dissimilarity-Basics.

Module 3:

Association Rules: Problem Definition, Frequent Item Set Generation, The Apriori Principle, Support and Confidence Measures, Association Rule Generation, Apriori Algorithm, The Partition Algorithms, FP-Growth Algorithms, Compact Representation of Frequent Item Set-Maximal Frequent Item Set, Closed Frequent Item Set.

Module 4:

Classification: Problem definition, General Approaches to solving a classification problem, Evaluation of Classifiers, Classification techniques, Decision trees, Naïve-Bayes Classifier, K-nearest neighbor classification-Clustering: Partitioning clustering K-Means Algorithm, Hierarchical Clustering-Algorithm- Agglomerative Methods and Divisive Methods, Basic Agglomerative Hierarchical Clustering Algorithm

Reference Books:

1. Jiawei Han and Micheline Kamber, Data Mining-Concepts and Techniques, Morgan Kaufmann Publishers, Elsevier, 3 Edition, 2012.

2. Pang-NingTan, Vipin Kumar, Michael Steinbanch Introduction to Data Mining, 2nd edition, Pearson Education, 2018.

3. Parteek Bhatia, Data Mining and Data Warehousing: Principles and Practical Techniques, Cambridge University Press, 2019.

4. Alex Berson and Stephen Smith, Data Warehousing, Data Mining & OLAP, McGraw Hill Education, 2017

24-478-0107: DATA ANALYSIS AND VISUALIZATION USING PYTHON

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Write an efficient program using python to perform routine and specialized data manipulation/management and analysis tasks	Evaluate
2.	Develop student's knowledge in the area of Data Science with emphasis on predictions using associated statistical techniques and software tools	Evaluate
3.	Develop various quantitative and classification predictive models Based on various regression and decision tree methods	Evaluate
4.	Apply specific statistical methods applicable to predictive analytics to identify new trends and patterns, uncover relationships, create forecasts, predict likelihood sand test predictive hypothesis	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3				
CO2		3			3
CO3				3	
CO4			3	3	

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to Data Acquisition-Applications-Process-Data Extraction-Data Cleaning and Annotation-Data Integration-Data Reduction-Data Transformation-Visualization-Introduction-Terminology-Basic Charts and Plots-Multivariate Data Visualization- Data Visualization Techniques-Pixel-Oriented Visualization Techniques-Geometric Projection Visualization Techniques-Icon-Based Visualization Techniques-Hierarchical Visualization Techniques-Visualizing Complex Data and Relations.

Module 2:

Data Visualization Tools-Rank Analysis Tools- Trend Analysis Tools-Multivariate Analysis Tools-Distribution Analysis Tools-Correlation Analysis Tools-Geographical Analysis Tools.

Module 3:

Regression model building framework: Problem definition, Data pre-processing, Model building, Diagnostics and validation Simple Linear Regression: Coefficient of determination, Significance tests, Residual Analysis, Confidence and Prediction Intervals.

Module 4:

Multiple Linear Regression: Coefficient of multiple coefficients of determination, Interpretation of regression coefficients, Categorical variables, Heteroscedasticity, Multi-collinearity, outliers, Auto regression and transformation of variables, Regression model building.

Reference Books:

1. Andy Kirk, Data Visualization a Handbook for Data Driven Design, Sage Publications, 2016
2. Philipp K.Janert, Gnuplotin Action, Understanding Data with Graphs, Manning Publications, 2010
3. Alberto Cordoba, "Understanding the Predictive Analytics Lifecycle", Wiley, 2014.

4. Eric Siegel, Thomas H. Davenport, "Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die", Wiley, 2013.

5. James R Evans, "Business Analytics-Methods, Models and Decisions", Pearson 2013.

6. R. N.Prasad, Seema Acharya, "Fundamentals of Business Analytics", Wiley, 2015.

7. Perkovie,L.(2011).Introduction to computing using python: An Application development focus. Wiley Publishing.

8. McKinney W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy and IPython. "OReilly Media, Inc."

24-478-0108: OPERATIONS AND SUPPLY CHAIN MANAGEMENT

After completion of this course the student should be able to:

1.	Describe operations management, objectives and Identify strategic approaches for competitive advantage	Understand
2.	Compute single-factor productivity and multi fact or productivity And identify the critical variables in enhancing productivity	Evaluate
3.	Understand the strategic importance of forecasting and Select appropriate method for forecasting in supply chains	Evaluate
4.	Describe basics of supply chain, performance and processes	Understand
5.	Formulate and Solve basic inventory order related problems in supply chain	Evaluate
6.	Understand and apply analytical tools for supply chain decisions	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1		1	2		1
CO2			2		
CO3	3	2		1	2
CO4			1		
CO5			1		
CO6	2	1	2		1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Operations, Logistics and Supply Chain Management: Definitions and Objectives- operations strategy and competitiveness-Basic concepts of operations management-types of manufacturing systems and their characteristics - Basics of Product and Process Design -Goods and Services. The Importance of Project Management - Project Planning, Scheduling and Controlling-PERT and CPM

Module 2:

Forecasting: The Strategic Importance of Forecasting - Steps in the Forecasting – Forecasting Approaches - Time-Series Forecasting -Associative Forecasting Methods: Regression and Correlation Analysis - Monitoring and Controlling Forecasts - Forecasting in the Service Sector. Process Analysis and Design - Process Redesign. The Strategic Importance of Location - Methods of Evaluating Location Alternatives - Job Design - Ergonomics and the Work Environment-Methods Analysis.

Module 3:

Understanding supply chain, supply chain performance - supply chain drivers and obstacles -Supply chain micro and macro processes - Push and pull systems - Aggregate planning in supply chain -planning supply and demand - managing predictable variability - Economic Order Quantity Models, Reorder Point Models - Manufacturing Planning and Control Systems.

Module 4:

Supply Chain Management Analytics: features of supply chain analytics - Techniques for Evaluating Supply Chains - Evaluating Disaster Risk in the Supply Chain - Managing the Bullwhip Effect - Supplier Selection Analysis - Transportation Mode Analysis, Warehouse Storage-Stochastic Inventory Models.

Reference Books:

1. Jay Heizer, Barry Render and Chuck Munson, Operations management: sustainability and supply chain management, Twelfth Edition, Pearson Education,Inc.2017.

2. Cecil C. Bozarth and Robert B. Handfield, Introduction to operations and supply chain management, Fifth edition, NY: Pearson, 2019.

3. Iman Rahimi et al., Big data analytics in supply chain management: theory and applications, CRC-Press,2021.

4. Sunil Chopra, Peter Meindl and Dharam Vir Kalra, Supply Chain Management Strategy, Planning and Operation, Sixth Edition, Pearson India, 2016.

5. Dmitry Ivanov, Alexander Tsipoulanidis and Jörn Schönberger, Global Supply Chain and Operations Management: A Decision-Oriented Introduction to the Creation of Value, Second Edition, Springer, 2019

24-478-0109: SYSTEM RELIABILITY AND RISK ANALYSIS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the concept of reliability, reliability data and model selection	Understand
2.	Examine classical non-parametric distribution estimation and Bayesian estimation procedure	Understand
3.	Understand system reliability analysis	Understand
4.	Distinguish different methods of evaluation of reliability	Analyze
5.	Understand accelerated life testing problems and its popular reliability models	Understand
6.	Examine AL model for time-dependent stress and PH model	Analyze
7.	Understand basic concepts in risk analysis	Understand
8.	Relate different risk assessment methods	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2		2
CO2				2	
CO3		2	2	2	1
CO4		2			
CO5		1	2		
CO6			2		
CO7	2	2			2
CO8		1			2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Component Reliability Analysis: Concept of reliability, Reliability data and model selection, Censored data, Classical non-parametric distribution estimation, Bayesian estimation procedure Estimation of the parameter of exponential distribution.

Module 2:

System Reliability Analysis: Reliability block diagram method, Failure tree and success tree methods, Event tree method, Master logistic diagram, Failure Mode and Effect Analysis.

Module 3:

Accelerated Life (AL) testing: Basic AL notions, Some popular AL reliability models, AL data analysis, AL model for time-dependent stress, Exploratory data analysis for time-dependent stress, PH model data analysis.

Module 4:

Risk Analysis: Determination of risk values, Quantitative risk assessment, probabilistic risk assessment, A simple fire protection risk analysis, precursor-based risk analysis.

Reference Books:

1. Modarres, M., Kaminskiy,M.P. and Krivtsov,V.(2017). Reliability Engineering and Risk Analysis–A Practical Guide, Third Edition, C RC Press, Boca Raton, FL.

2. Rao S.S.(1992)Reliability-based Design. McGraw-Hill, Inc., USA.

3. Gnedenko,B., Pavlov,I. and Ushakov,I. (1999). Statistical Reliability Engineering, John Wiley & Sons, Inc.,USA.

4. Zio,E. (2007). An introduction to basics of reliability and risk analysis, World Scientific Publishing Co.Pvt Ltd., Singapore

5. Birolini,A.(2007). Reliability engineering–Theory and Practice, Fifth Edition, Springer-Verlag, Berlin.

24-478-0201: SIMULATION MODELLING AND ANALYSIS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand how simulation works, application areas and the types of software that are available for simulation modelling	Understand
2.	Develop a conceptual model for a given problem	Evaluate
3.	Apply general modelling principles of simulation	Apply
4.	Create credible models of systems	Create
5.	Evaluate model's models validation using appropriate methods	Evaluate

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2		3
CO2	2	1	2		2
CO3	2	2			2
CO4		2		2	2
CO5		1		2	2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Simulation: Definition, areas of application, System: discrete and continuous Systems, Model of System, Common types of simulation models and applications, Steps in a simulation study. General principles of discrete event-Simulation, Event scheduling/time advance algorithms, World views, Simulation examples: single channel queues newspaper selling problem, reliability problem, lead-time demand.

Module 2:

Random number generation, Properties of random numbers, Techniques of generation of pseudo–random numbers, Test for random numbers, Random variate generation: Inverse transform technique, Convolution method, Acceptance–rejection technique. Queuing Models, Long run measures of performance, Steady state models: M/G/1, M/M/1/N/∞,M/M/c/∞/∞ and M/M/c/K/K.

Module 3:

Simulation of manufacturing and material handling systems: Modeling of manufacturing system, Material handling systems, Goals and performance measurement, Modeling of downtimes and failures, Trace driven models; Features of Simulation languages: Promodel –Extend - Auto Mod – Taylor II – Witness, Simul8– AIM – Arena, Basic introduction to agent-based simulation and applications.

Module 4:

Input modeling, Verification, Calibration and validation, Face validity, Validation of model assumption, Validating input-output. Analysis of simulation data: Output analysis for terminating simulations, Output analysis for steady state simulations.

Reference Books:

1. Jerry Banks et.al.: Discrete–Event System Simulation, Fifth Edition, Prentice Hall ,2009.
2. Law A.M. Simulation Modeling and Analysis, Fifth edition, McGraw Hill New York, 2015.
3. Robinson S: Simulation, The Practice of Model Development and Use, Red Globe Press; Second edition, 2014.
4. Gordon G, System Simulation, Second Edition, Prentice Hall, 1978

24-478-0202: MACHINE LEARNING

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understanding of the basic concepts of Machine Learning	Understand
2.	Solve the problems using various machine learning techniques	Apply
3.	Describe the underlying mathematical relationships within across Machine Learning algorithms and the paradigms of supervised and unsupervised learning	Evaluate
4.	Identify machine learning techniques suitable for a given problem	Analysis
5.	Understand neural networks, including MLPs, activation functions and back propagation. Gain basic knowledge of CNNs for image recognition and RNNs	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2		3	3
CO2	3		2	3	3
CO3	2				3
CO4	3		2	3	3
CO5	3				3

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Review of linear algebra: Vectors, Matrices and Eigen values; Probability and Optimization: Random Variables, Discrete and Continuous distributions, Gradient, Hessian, Least Squares, Genetic Algorithms.

Module 2:

Machine Learning: Introduction, Basic Definitions, Types of Learning, Handling Multicollinearity, Residual Analysis, Supervised Learning- Linear Regression, Logistic Regression; Lasso and Ridge Regularization; Bias and Variance; Overfitting and Underfitting.

Module 3:

Supervised Learning: Classification-, Decision Tree, Native Bayes, K-Nearest Neighborhood, Support Vector Machine; Evaluation Matrices for Classifier models.
Dimensionality Reduction: Recursive Feature Elimination, Principal Component Analysis

Module 4:

Reinforcement Learning: Introduction, Elements of Reinforcement Learning, Q Learning, Nondeterministic Rewards and Actions, Temporal Difference Learning Overview of Neural Networks: Multilayer Perceptrons (MLPs) and feed forward networks - Activation functions and their role in neural network computation - Training neural networks: Back propagation algorithm - Basic introduction to Convolutional Neural Networks (CNNs) for image recognition and Recurrent Neural Networks (RNNs).

Reference Books:

1. Kroese, D. P., Botev, Z., Taimre, T., Vaisman, R. (2019). Data Science and Machine Learning: Mathematical and Statistical Methods. United States: CRC Press.

2. Watt, J., Borhani, R., Katsaggelos, A. K. (2020). Machine Learning Refined: Foundations, Algorithms, and Applications. United States: Cambridge University Press.

3. Deisenroth, M. P., Faisal, A. A., Ong, C. S. (2020). Mathematics for Machine Learning. United Kingdom: Cambridge University Press.

4. Tom M. Mitchell (1997). Machine Learning, New York, N Y: Mc Grow-Hill.

5. Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Switzerland: Springer New York.

6. Langley P. (1995). Elements of Machine Learning, Morgan Kaufmann.

7. James K.C.(2024)Regression Modelling with Classical and Statistical Learning Methods: An Easy Guide for Data Scientists, Business Analysts and Engineers using Python. Amazon Kindle Publishing, .

8. Charu C. Aggarwal (2018). Neural Networks and Deep Learning: A Textbook. Springer

24-478-0203: MULTI VARIATE ANALYSIS AND STATISTICAL TECHNIQUES FOR DATA MINING

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand basic concepts of data mining	Understand
2.	Understand different methods of data pre-processing, data cleaning and data reduction	Understand
3.	Apply principal component analysis	Apply
4.	Perform factor analysis and canonical correlation	Evaluate
5.	Examine classification problems	Evaluate
6.	Perform MANOVA	Evaluate
7.	Apply different tests of multivariate populations and associated problems	Apply
8.	Apply cluster analysis and different methods of it	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		1		2
CO2	2				2
CO3	2	2		2	2
CO4	2	2		2	2
CO5				2	2
CO6		2		1	2
CO7		2			
CO8		2		2	2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to data mining; data types for Data mining, Data mining functionalities -Concept/class description: characterization and discrimination, Association analysis, Classification and prediction, Clustering analysis, Evolution and deviation analysis, Data Pre-processing, Data cleaning, Data integration and transformation, Data reduction, Discretization and concept hierarchy generation.

Module 2:

Dimension Reduction methods: Profile Analysis and the associated tests, Principal Component Analysis-Method of extraction-properties, the associated tests, Factor Analysis-Orthogonal Model-Estimation of factor loadings, Canonical variates and canonical correlation, use, estimation and computation.

Module 3:

Classification problems: Discriminant Analysis-Bayes' procedure, Classification into one of the two populations (Normal distribution only), Classification into several populations(Normal distribution only), Fishers linear discriminant function and its associated tests, Cluster Analysis: proximity measures, Hierarchical and non-hierarchical methods.

Module 4:

Multivariate General linear models- MANOVA (one way and two way), Wilk's Λ, Rau's U, Pillai's trace, Hotelling-Lawley trace, Roy's Maximum Root Statistics (Concepts only), Tests-Independence of sets of variables, Equality of dispersion matrices and Sphericity test.

Reference Books:

1. JiaweiHan, Micheline Kamber, JianPei (2012): Data Mining: Concepts and Techniques, 3rd Edition, Morgan Kaufmann Publishers, Elsevier Inc., USA.

2. Johnson R.A. and Wichern D.W. (2008) Applied Multivariate Statistical Analysis, 6th Edition, Pearson Education.

3. Rencher A.C.(2012) Methods of Multivariate Analysis. 3rd Edition, John Wiley.

4. Johnson D.E.(1998). Applied Multivariate Methods for Data Analysts, Duxbury Press, USA-An International Thomson Publishing Company.

5. Morrison,F (2003). Multivariate Statistical Methods, Brooks/Cole, 4thRevised Edition, McGrawHill Book Company.

6. Srivastava M.S. and KhatriC.G.(2002): Methods of Multivariate Statistics, John Wiley & Sons, NewYork.

7. Anderson T.W.(2010). An Introduction to Multivariate Statistical Analysis, 3rd Edition, JohnWiley.

8. Seber G.F.(2004) Multivariate Observations, John Wiley.

24-478-0204: R/R-STUDIO PROGRAMMING – PRACTICAL II

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understanding of basic commands in R programming	Understand
2.	Practice different problems in regression analysis using R programme	Apply
3.	Explain different optimization problems using R programme	Evaluate
4.	Apply the R programming from a statistical perspective	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2		2
CO2	2		3	3	2
CO3	2		2	3	2
CO4	2	3			2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to R: basic commands, graphics, indexing data, loading data; Regression: linear regression, test of significance, residual analysis, polynomial regression, qualitative predictor, logistic-regression

Module 2:

Resampling methods: cross validation, bootstrap; Subset selection: best subset selection, forward and backward stepwise selection, choosing among models using the validation; Markov chain Monte Carlo.

Module 3:

Optimization in R: Common R Packages for Linear, Quadratic and Non-linear optimization, Built-in Optimization functions, Linear Programming in R-lpsolve

Module 4:

Quadratic Programming: quadprog. Non-Linear Optimization:One-dimensional:Golden Section Search; Multi-dimensional: Gradient-based, Hessian based, Non-gradient based

Reference Books:

1. G. James, D. Witten,T. Hastie and R.Tibshirani (2013). An Introduction to Statistical Learning: with Applications in R (Springer Texts in Statistics), Springer.
2. W John Braun, Duncan J (2008). A First Course in Statistical Programming with R, Murdoch, Cambridge University, Press.

24-478-0205: OPTIMIZATION TECHNIQUES

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the basic concepts of linear programming	Understand
2.	Distinguish different methods of solving nonlinear programming problem	Analyze
3.	Understand genetic algorithms and associated properties	Understand
4.	Distinguish different types of advanced genetic algorithms and applications	Analyze
5.	Understand differential evolution and its principle	Understand
6.	Distinguish different algorithms of differential evolution	Analyze
7.	Understand particle swarm optimization methods	Understand
8.	Understand protein folding problems and protein structure analysis	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	3		3
CO2	2	2	2	2	
CO3	1	1			
CO4	1	1			
CO5		1			
CO6		1			
CO7	1	1			
CO8		1			

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to optimization: formulation of optimization problems-Review of classical methods-Linear programming-Nonlinear programming-Constraint optimality criteria-constrained optimization-Population based optimization techniques.

Module 2:

Genetic Algorithm-Introduction: Working principle-Representation-selection-fitness assignment reproduction-cross over-mutation-constraint handling-advanced genetic algorithms-Applications-Artificial Immune Algorithm-Introduction-Clonal selection algorithm- Negative selection algorithm-Immune network algorithms-Dendritic cell algorithms

Module 3:

Differential Evolution: Introduction-Working principles-parameter selection-advanced algorithms in Differential evolution–Biogeography-Based Optimization-Introduction-Working Principles-Algorithmic variations

Module 4:

Particle Swarm Optimization: Introduction-Working principles-Parameter selection- Neighborhoods and Topologies-Convergence-Artificial Bee Colony Algorithm-Introduction-Working principles-Applications Cuckoo search based algorithm-Introduction- Working principles- Random walks and the step size-Modified cuckoo search, Hybrid Algorithms: Concepts- divide and conquer- decrease and conquer-HPABC-HBABC-HDABC-HGABC-Shuffled Frog Leaping Algorithm—Working principles-Parameters-Grenade Explosion Algorithm-Working principle-Applications.

Reference Books:

1. Rao S.S. (2019).Engineering optimization: theory and practice. John Wiley & Sons.
2. Venkata Rao R.(2016). Teaching Learning Based Optimization Algorithm: And Its Engineering Applications, 1e, Springer.
3. Simon D. (2013). Evolutionary optimization algorithms. John Wiley & Sons.
4. Yang X.S.(2010). Engineering optimization: An Introduction with Metaheuristic Applications. John Wiley & Sons.

24-478-0206: DESIGN OF EXPERIMENTS (INTEGRATED WITH R)

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Illustrate the statistical tool-Analysis of Variance	Apply
2.	Describe the different experimental designs	Understand
3.	Describe concepts of Taguchi experiments and orthogonal array	Understand
4.	Apply design of experiments to product design, Taguchi concept of quality, Relibility enhancement techniques and accelerated life testing	Apply
5.	Be able to execute using R	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3		1	
CO2	2	3	2		2
CO3	1	2	2		2
CO4	1	2	2		2
CO5	1			2	

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Analysis of variance: General Linear Model, One-way analysis of variance, Two way analysis of variance, Interaction, Confidence intervals in one-way and two-way analysis of variance, Multiple treatment comparisons, Random ordering of the experimental sequence, CRD,RBD.

Module 2:

Factorial experiments: Simple and main effects, Factorial applied to randomized block designs, Taguchi experiments, Generalization of orthogonal arrays, Dealing with interactions, Confounding, Other designs. Response surface Methodology, First and second order models.

Module 3:

Application of design of experiments, Product design, Managing the uncontrollable factors, Type of uncontrollable factors, Use of outer arrays for concurrent engineering, Application of design of experiments to reliability assurance.

Module 4:

Accelerated Life Testing, Environmental and operating stress, Interpreting data from accelerated tests, Developing an integrated reliability test program, Reliability improvements with design of experiments.

Reference Books:

1. D.C. Montgomery (1997): Design and Analysis of Experiments, John Wiley and Sons, New York.
2. Lawson John (2015): Design and Analysis of Experiments with R; CRC Press.
3. Bloyd W. Condra (1993): Reliability Improvements with Design of Experiments, Marcel Dekker.
4. R. M Bethea and R. Rhireheart (1991): Applied Engineering Statistics, Marcel Dekker.
5. Alain Villemeur (1992): Reliability Availability, Maintainability and Safety Assessment Vol.2, John Wiley ands ons.
6. E. Daniel (1976): Application of Statistics to Industrial Experimentation, John Wiley and Sons.
7. T.J Lorenzen and V.L. Anderson (1993): Design of Experiment, Marcel Dekker.

24-478-0207: ARTIFICIAL INTELLIGENCE AND DEEP LEARNING

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Discuss the history, current applications, future challenges and the controversies in artificial intelligence	Understand
2.	Apply principle of AI in the design of an agent and model its actions	Apply
3.	Design a heuristic algorithm for search problems	Apply
4.	Analyze and represent the fact using logic for a given scenario	Apply
5.	Represent uncertainty using probabilistic models	Evaluate
6.	Describe the basics of learning and deep learning	Understand
7.	Apply principles of Convolution neural network to practical problems	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1			1
CO2	3	3		2	
CO3	3	2		2	2
CO4			2	1	
CO5		1			1
CO6	3	3		2	3
CO7	3	3	3	3	3

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction: AI:, Brief history-Agents and rationality, task environments, agent architecture Types- Search and Knowledge representation - Search spaces, Uninformed and informed search.

Module 2:

Techniques: Hill climbing, simulated annealing, genetic algorithms-Logic based representations (PL, FoL) and inference, Prolog – Rule based representations, forward and backward chaining, matching algorithms – Probabilistic reasoning and uncertainty - Bayes networks and reasoning with them.

Module 3:

Learning: Uncertainty and methods to handle it - Forms of learning - Statistical methods: naive-Bayes, nearest neighbors, kernel, neural network models, noise and over fitting, Decision trees, inductive learning.

Module 4:

Introduction to Convolution Neural Networks and Recurrent Neural Networks – Deep Learning, Autoencoders and unsupervised learning - Stacked auto-encoders and semi-supervised learning -Regularization – Dropout and Batch normalization.

Reference Books:

1. Russel S. and Norvig P. (2015), Artificial Intelligence: A Modern Approach, 3rd Edition, Pearson Education Limited, 2016
2. Goodfellow, I., Bengio,Y. and Courville, A., Deep Learning, The MIT Press, 2016.
3. DavidPoole, Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
4. Keith Frankish, William M. Ramsey (eds) The Cambridge Handbook of Artificial Intelligence, Cambridge University Press, 2014.

24-478-0208: NATURAL LANGUAGE PROCESSING

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Describe the basics of language processing technologies for Processing the text	Understand
2.	Acquire knowledge on text data analytics using language models	Evaluate
3.	Process the text data at syntactic and semantic level	Evaluate
4.	Extract key information from text data	Apply
5.	Analyze the text content to provide predictions related to a specific domain using language models	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1		2	3
CO2	1			3	3
CO3	2		1	3	3
CO4	3			1	3
CO5	2		3		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to NLP, Knowledge Acquisition, Regular expression (RE) and Text Processing, Word Tokenization, Word Normalization and Word Stemming, Sentence Segmentation, Edit Distance, Word Alignment Problem and Statistical Machine Translation (MT),Word Alignment Problem, Parallel Corpora, Decoding, Evaluation, Statistical MT, Modern MT Systems

Module 2:

Language Modeling, Introduction to N-grams, Estimating N-gram Probabilities, Evaluation and Perplexity, Generalization and Zeros, Interpolation, Good-Turing Smoothing, Kneser- Ney Smoothing, Spelling Correction, Noisy-Channel Model for Spelling

Module 3:

Text Classification and Sentiment Analysis, Naïve Bayes Classifier, Precision, Recall and the F measure, Text Classification, Evaluation, Sentiment Analysis - Baseline Algorithm ,Learning Sentiment Lexicons and Discriminative Classifier - Maximum Entropy Classifier, Generative vs. Discriminative Model Making features from text, Feature-based Linear Classifier, Problem of Over counting evidence, Named Entity Recognition (NER) and Maximum Entropy Sequence Model.

Module 4:

Introduction to Information Extraction, NER and Evaluation of NER, Sequence Models for NER,Maximum Entropy Sequence Model, Relation extraction by using patterns, Supervised, Semi-supervised and Unsupervised Relation Extraction, Advanced Maximum Entropy Models, Parts of Speech (POS) Tagging , Sequence Models for POS Tagging, Parsing, Syntactic Parsing - Constituency vs Dependency, Context Free Grammar (CFG) and PCFG, Grammar Transforms, CKY Parsing, Lexicalized Parsing, Lexicalization and PCFGs, Charniak' Model, Unlexicalized PCFGs, Latent Variable PCFGs, Context Sensitive Grammar(CSG).

Reference Books:

1. Jurafsky D. and Martin J.H. Speech and language processing.Vol.3.Prentice Hall, 2014.

2. JanŽižka, František Dařena and Arnošt Svoboda, Text mining with machine learning : principles and techniques. CRC Press, 2019.

3. Bird S., Klein E. & Loper, Natural language processing with Python: analyzing text witht the natural language toolkit. O'Reilly Media, Inc,2009..

4. Manning C.D., Manning, C.D. & Schütze, H Foundations of statistical natural language processing. MIT press, 1999.

24-478-0209: FINANCIAL RISK ANALYTICS AND MANAGEMENT

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Describe the financial risk management process and identify key factors that affect interest rates, exchange rates and commodity prices	Evaluate
2.	Understand and evaluate ways to manage the different risks pertaining to stock market and its instruments	Apply
3.	Identify the various risks faced by an organization such as credit risk, operational risk, and systemic risk	Evaluate
4.	Develop an organizational profile to support risk management policy and evaluate opportunities to develop or refine a risk management policy	Evaluate
5.	Identify and solve legal issues that impact financial and other risk affecting business	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1		2		2
CO2	1	2	2		2
CO3	1		2		2
CO4	1		2		2
CO5	1		2		2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to Risk-Understanding Risk-Nature of Risk, Source of Risk, Need for risk management, Benefits of Risk Management, Risk Management approaches. Risk Classification- credit risk, market risk, operational risk and other risk

Module 2:

Risk Measurements-Measurement of Risk-credit risk measurement, market risk measurement, interest rate risk measurement, Asset liability management, measurement of operational risk

Module 3:

Risk Management- Risk management- Managing credit risk, managing operational risk, managing market risk, insurance

Module 4:

Risk in Instruments -Tools for risk management – Derivatives, combinations of derivative instruments - Neutral and volatile strategies - credit derivatives - credit ratings- Regulation and Other Issues: Other issues in risk management – Regulatory framework, Basel committee, legal issues, accounting issues, tax issues, MIS and reporting, integrated risk management

Reference Books:

1. Dun, Bradstreet, Financial Risk Management, TMH, 2006.
2. Jimmy Skoglund and Wei Chen, Financial risk management: applications in market, credit, asset and liability management and firmwide risk, Wiley finance series, 2015

3. McNeil A.J., Frey, R. and Embrechts, P. Quantitative Risk Management, Princeton University Press, Oxford, 2005.

4. Richard Apostolik and Christopher Donohue, Foundations of Financial Risk: An Over view of Financial Risk and Risk-Based Regulation, Wiley; 2015

5. JohnCHull, Risk management and Financial Institutions, Pearson, 2015.

6. Aswath Damodharan, Strategic Risk Taking, Pearson, 2008.

24-478-0210: MARKETING AND HR ANALYTICS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Interpret the benefits and objectives of marketing analytics	Evaluate
2.	Apply metrics-driven techniques to improve marketing decisions	Apply
3.	Design appropriate hands-on computer models and metrics	Apply
4.	Identify necessary skills to carry out the personnel roles in the domain of HR	Evaluate
5.	Apply HR analytics to improve organizational performance by providing better insights on human resources data	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1		1
CO2	1		1		1
CO3	1		3		1
CO4	1	1			
CO5	1		2		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Introduction to Marketing Analytics – Models & Metrics – Market Insight – Terminologies – Data Sources - Market sizing - PESTLE analysis – Introduction to forecasting tools.

Module 2:

Market Segmentation - Segment Targeting and Positioning- Competitor - identification and information gathering – Competitive analysis – Competitive -actions - Cluster Analysis –Classification Trees-Conjoint Analysis, Products, Attributes, and Levels, Full Profile Conjoint Analysis- Discrete Choice Analysis- Random Utility Theory.

Module 3:

Introduction to HR Analytics: Overview of HR Process, HR as an expense, the analytics and prediction Strategic Human capital measures, business analysis and rational action – Benefits of Analytics in Improving HR Process, Intersection of people and profits -Technology Used, SWOT Analysis of HR analytics.

Module 4:

Employee Engagement Measurement Process: Attracting, motivating and retaining people Organization Gap and Alignment Analytics - Recruitment Analytics and On Boarding Analytics - Staffing Analytics - Performance & Skill Gap Analytics - Compensation & Benefit Analytics Training & Learning Analytics - Promotion and Succession Planning Analytics Compliance Analytics Attrition & Retention Analytics - Identification of Key Business Objectives Conducting HR Practice

Reference Books:

1. Wayne L.Winston, Marketing Analytics: Data-Driven Techniques with Microsoft® Excel, Published by John Wiley & Sons, 2014
2. Jac FITZ-ENZ, The New HR Analytics: Predicting the Economic Value of Your Company's Human Capital Investments, American Management Association, 2010.
3. JohnW.Boudreau, Beyond HR: The New Science of Human Capital, Harvard Business School Press, 2007.
4. Stephan Sorger, Marketing Analytics: Strategic Models and Metrics, 1st Edition, Create Space Independent Publishing Platform, ISBN: 1481900307, 2013.

24-478-0211: BIOINFORMATICS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand features of molecular biology	Understand
2.	Distinguish the genomic-genetic synthesis, translation-transcription-protein synthesis	Analyze
3.	Understand pair wise sequence alignment, PAM and BLOSSUM matrices	Understand
4.	Distinguish different dynamic programming methods	Analyze

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	3		1
CO2		2	2		1
CO3		2		2	1
CO4		2			1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Molecular Biology and Bioinformatics: Introduction to molecular biology- Nucleic acids-DNA-RNA Proteins-Gene-Genome-Genetic synthesis -Translation-Transcription-Protein synthesis-Chromosomes-Maps and sequences-Human genome project.

Module 2:

Sequence alignment and database search: Pair-wise sequence alignment- Substitution matrices -PAM and BLOSSUM matrices, Dot plots - Local and global alignment theory -Dynamic programming methods -FASTA and BLAST algorithms – database search using BLAST and FASTA - Similarity & distance -Similarity scores – Weight matrices - Heuristic method - Hidden Markov Models and their application in sequence analysis.

Module 3:

Phylogenetic trees: Introduction -Dendrogram construction/Molecular Phylogenetics/Tree definitions/Optimality criteria/Distance matrix methods and maximum parsimony/Multiple/ sequence alignments- tree alignments, star alignments, pattern in pair wise alignment Genetic algorithm.

Module 4:

DNA Micro-arrays and Gene Expression- Gene profiling- DNA Microarray technology-Gene regulatory network-Heuristic Algorithms for GRN- S-system model – Computational methods for pathways and system biology-metabolic pathways- genetic pathways- signaling pathways, Molecular Structure Prediction- RNA secondary structure prediction-Protein Folding problems-Protein threading- Protein structure analysis.

Reference Books:

1. Ghosh,Z.,&Mallick,B.(2008). Bioinformatics: Principles and Applications.Rastogi S. C., Rastogi, P., & Mendiratta, N. (2008). Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery 3RdEd. PHI Learning Pvt. Ltd..
2. Jones N.C., Pevzner,P.A. & Pevzner,P. (2004). An introduction to Bioinformatics Algorithms. MIT press.

24-478-0212: BIG DATA TECHNOLOGY

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Process data in Big Data platform and explore the big data analytics Techniques for business applications	Analyze
2.	Analyze Map Reduce technologies in big data analytics	Analyze
3.	Learn to build and maintain reliable, scalable, distributed systems with Apache Hadoop	Evaluate
4.	Design efficient algorithms for stream data mining on big data platform	Evaluate

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3			1	3
CO2	2			3	3
CO3	2		1	3	3
CO4	3			3	3

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

NoSQL Database: NoSQL Databases – Schema less Models, Increasing Flexibility for Data Manipulation-Key Value Stores, Document Stores, Tabular Stores, Object Data Stores –Graph Databases, Big Data: Evolution of Big data, Best Practices for Big data Analytics - Big data characteristics - Big Data Use Cases, Characteristics of Big Data Applications, Big data for twitter, Big data for E-Commerce blogs.

Module 2:

Big Data Modelling, Map Reduce algorithm. Hadoop Introduction: Apache Hadoop & Hadoop Ecosystem – Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce-Data Serialization, Hadoop Architecture.

Module 3:

HDFS performance and tuning, Pig: Introduction to PIG, Execution Modes of Pig, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive : Hive Shell, Hive Services, HiveQL, Tables, Querying Data and User Defined Functions. Hbase: HBasics, Concepts, Clients, Example, Spark

Module 4:

Mining Data Streams: Introduction to Streams Concepts, Stream Data Model and Architecture - Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream –Real time Analytics Platform (RTAP) applications, Case Studies, Real Time Sentiment Analysis-Stock Market Predictions.

Reference Books:

1. Jure Leskovec, Anand Rajaramanand Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2014.
2. Arshdeep Bahga & VijayMadisetti,BigDataAnalytics:AHands-OnApproach,2019
3. Tom White, Hadoop: The Definitive Guide, 4th edition O'Reily Publications, 2015
4. Jules S.Damji, Brooke Wenig, TathagataDas,andDennyLee,LearningSpark:Lightning-FastDataAnalytics, O-ReillyPublications,2020

5. David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL and Graph, 2013.

6. Bart Baesens, Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.

7. Dietmar Jannach, Markus Zanker, Alexander Felfernig and Gerhard Friedrich, Recommender Systems: An Introduction, Cambridge University Press, 2010.

20-478-0301: BUSINESS ANALYTICS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand and explore problems in business	Evaluate
2.	Summarize the evolution of business analytics and explain the concepts of business intelligence, operations research and management science, and decision support systems	Evaluate
3.	Explain the purpose of regression analysis and provide examples in business	Understand
4.	Apply a systematic approach to build good regression models	Apply
5.	Apply the appropriate forecasting technique in a given business situation	Apply
6.	Apply association rule mining, k- Nearest Neighbors, discriminant analysis, and logistic regression in business applications such as Market basket analysis.	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3		3		2
CO2			2		2
CO3				2	2
CO4	3	3		2	2
CO5	3	3		2	2
CO6	3			2	2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Business Analytics: Evolution of Business Analytics, Impacts and Challenges - Big Data - Metrics and Data Classification - Data Reliability and Validity - Models in Business Analytics - Decision Models - Model, Assumptions - Uncertainty and Risk - Prescriptive Decision Models - Problem Solving with Analytics - Recognizing a Problem - Defining the Problem - Structuring the Problem - Analyzing the Problem - Interpreting Results and implementation.

Module 2:

Modeling Relationships and Trends in Data- Regression applications in industry and business- Least-Squares Regression - Regression Analysis of Variance-Testing Hypotheses for Regression Coefficients –Confidence Intervals for Regression Coefficients- Residual Analysis and Regression Assumptions- Checking Assumptions- Multiple Linear Regression, Polynomial regression-diagnostics, transformations and model improvements - Regression with categorical independent variables.

Module 3:

Forecasting Techniques - Qualitative and Judgmental Forecasting - Forecasting Models for Stationary Time Series - Moving Average Models-Error Metrics and Forecast Accuracy - Exponential Smoothing Models Regression - Based Forecasting for Time Series with a Linear Trend -Forecasting Time Series with Seasonality - Regression - Based Seasonal Forecasting Models - Holt-Winters Forecasting for Seasonal Time Series - Holt-Winters Models for Forecasting Time Series with Seasonality and Trend - ARMA and ARIMA Modeling and Forecasting - selecting appropriate Time - Series based Forecasting Models - Regression Forecasting with Causal Variables.

Module 4:

Introduction to Data Mining - The Scope of Data Mining -Data Exploration and Reduction- Sampling - Data Visualization- Dirty Data - Cluster Analysis -Classification - Measuring Classification Performance-Using Training and Validation Data-Classifying New Data- k-Nearest Neighbors (k-NN) - Discriminant Analysis -Logistic Regression-Association Rule Mining-Cause-and-Effect Modeling

Reference Books:

1. Galit Shmueli et al, Data Mining For Business Analytics: Concepts, Techniques, and Applications in R John Wiley & Son, 2018
2. J.R.Evans, Business Analytics, Pearson Education; Second edition, 2017
3. Jeffrey D Camm, Essentials of Business Analytics; South Western, 2015
4. S.Christian Albright and Wayne L. Winston, Business Analytics: Data Analysis & Decision Making, Cengage Learning; Sixth Edition, 2017.
5. K.C James, Regression Modelling with Classical and Statistical Learning Methods: An Easy Guide for Data Scientists, Business Analysts and Engineers using Python. Amazon Kindle Publishing, 2024.
6. Hanke, J. E.,& Wichern, D. W. Business Forecasting: Pearson New International Edition. Pearson Higher Ed, 2013.

24-478-0303: STATISTICAL FORECASTING METHODS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Choose a suitable model for the given time series	Evaluate
2.	Define forecasts under various Optimization criteria such as MMSE ,MAP, MAPE etc.	Remember
3.	Prediction by suitable smoothing methods	Evaluate
4.	Compute forecasts using regression and time series models	Apply
5.	Evaluate the forecasts using suitable measures	Evaluate
6.	Prediction using logistic regression, intervention models and neural networks	Evaluate
7.	Interpret the model performance based on residuals	Evaluate
8.	Choose forecast methods for a given data	Evaluate

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2			3
CO2	2	2			2
CO3		2		2	2
CO4	1	2		2	2
CO5	2	2		2	
CO6	2	2		2	2
CO7		2			2
CO8	2	1			

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Need for forecasting, Basic forecasting tools, Time series and cross-sectional data, Graphical and numerical summaries, Measuring forecast accuracy, Transformations and adjustments. Time series decomposition: principle of decomposition, moving averages. Exponential smoothing: single, double, Holt's and Holt – Winters' smoothing methods.

Module 2:

Simple regression: model and properties, Inference and forecasting with simple regression. Multiple linear regression: Method of analysis and examples. Variable selection methods, Multicollinearity, multiple linear regression and forecasting, Regression with correlated errors, Durbin–Watson test.

Module 3:

Box-Jenkins Methodology for forecasting: Tests for independence and stationarity, methods of removing non-stationary, ARMA and ARIMA models for time series: Identification, estimation and diagnosis methods. Forecasting with ARIMA models.

Module 4:

Modelling and forecasting of Regression models with ARIMA errors: Dynamic regression models, Intervention analysis, non-linear models: logistic regression, Neural network forecasting.

Reference Books:

1. S.Makridakis, S.C.Wheelwright and R.J.Hyndman (2005): Forecasting Methods and Applications. 3rd Edition. John Wiley and Sons, New York.

2. B.Abraham and J.Ledolter (2006): Introduction to Regression Modeling Thomson, Canada

3. B.Abraham and J. Ledolter (1983).Statistical Methods for Forecasing. Wiley, NewYork.

4. D.C.Montgomery, E.A.Peckand G.G.Vining (2003): Introduction to Linear Regression Analysis.Wiley

24-478-0304: QUALITY MANAGEMENT AND SIX SIGMA

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the basic ideas of quality and quality management and the necessity for quality improvement for organizational excellence	Understand
2.	Understand various quality costs and see how quality Improvement efforts could reduce costs in industries	Analyze
3.	Evaluate current level of quality in industries	Evaluate
4.	Know Project Management Using the DMAIC and DMADV Models	Apply
5.	Understand and apply various analytical tools of quality, Six Sigma and quality management systems	Apply
6.	Understand and apply appropriate statistical tools for quality control	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2			1
CO2		1	3		1
CO3		1			1
CO4	2	2	2		1
CO5	2	2	2		1

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Basics of Quality and Total Quality Management – Scope and Objectives - Models and Frameworks for TQM- Analysis of Quality Costs-Quality Improvement and Cost Reduction. Strategic Quality Management – Quality Policy – Training for Quality –Quality Teams – Developing Quality Culture – TQM & JIT- Quality System: ISO 9000/Q S9000 And ISO 14000.

Module 2:

Introduction to Six Sigma-Six Sigma as a Statistical Measure-The DMAIC Process–Basics of Lean concepts, Strategic Planning and Deployment, Project Selection, Lean Six Sigma Team and Project Management - Design for Six Sigma (DFSS) - Phases of DFSS - Process of DFSS.

Module 3:

Analytics Tools: Basic concepts of SWOT, Affinity Diagram, SIPOC, VOC, CTQ, Pareto Diagram, Prioritization Matrix, Monte Carlo Analysis, Gauge R&R Methods, Cause-and-Effect Analysis, Quality function deployment (QFD), Bench Marking, FMEA, DOE, VSM, Regression, RSM.

Module 4:

Quality Control: Basic concepts of Acceptance sampling, Quality using SPC Charting-Common Causes and Assignable Causes- Rational Subgroups, Control Limits, Control charts for Attributes and Variables - Cumulative Sum Chart - EWMA Chart - Process Capability Studies.

Reference Books:

1. Erick C. Jones, Quality Management for Organizations Using Lean Six Sigma Techniques,CRCPress,2014
2. Theodore T. Allen, Introduction to Engineering Statistics and Lean Six Sigma Statistical Quality Control and Design of Experiments and Systems, Third Edition, Springer-Verlag London Ltd.,2019

3. K. Muralidharan, Six Sigma for Organizational Excellence A Statistical Approach, Springer India,2015

4. Amitava Mitra, Fundamentals of Quality Control and Improvement Fourth Edition, John Wiley& Sons Inc.,2016

5. Juran,J. M and Gryna,F.M: Quality Planning and Analysis for Enterprise Quality, 5th Edition. McGraw Hill, 2007.

24-478-0305: APPLIED LONGITUDINAL ANALYSIS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand features of longitudinal data	Understand
2.	Understand the descriptive methods of analysis and modelling mean and covariance	Apply
3.	Understand linear mixed effects models	Understand
4.	Distinguish fixed effects versus random effects	Analyze
5.	Apply residual analysis and diagnostics	Apply
6.	Distinguish GLM and generalized linear mixed effects models	Analyze
7.	Examine missing data and dropout	Analyze
8.	Understand multilevel data	Understand

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1			2	2	2
CO2					2
CO3		1			2
CO4		1	1	1	2
CO5	3			2	2
CO6	3			3	2
CO7	3			3	2
CO8	3			3	2

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Longitudinal Data-Introduction, Defining features of Longitudinal data, Linear models for Longitudinal Data-Simple descriptive methods of analysis, modelling the mean, modelling the covariance, estimation, missing data, modelling the.

Module 2:

Linear mixed effects models-random effects covariance structure, two-stage random effects formulation, fixed effects versus random effects models, residual analyses and diagnostics-residuals, transformed residuals, aggregating residuals, semi-variogram.

Module 3:

Salient features of GLM, ordinal regression models, overdispersion, marginal models, generalized estimating equations, generalized linear mixed effects models, incorporating random effects in GLM, interpretation of regression parameters.

Module 4:

Missing data and dropout- multiple imputation, inverse probability weighted methods, repeated measures and related designs, multiple source data, Multilevel data, multilevel linear models, multilevel GLM.

Reference Books:

1. Fitzmaurice, G.M., Laird, N.M. and Ware, J.H. (2011). Applied Longitudinal Analysis, 2nd Edition, John Wiley and Sons, New Jersey.

2. Diggle, P.J., Heagerty, P., Yiang, K-Y., Zeger, S.L. (2002). Analysis of longitudinal data. Oxford University Press.

3. Press, E.W. (2004). Longitudinal and Panel Data-Analysis and Applications in the Social Sciences, Cambridge University Press, UK.

4. Hedeker.D. and Gibbons, R.D. (2006). Longitudinal Data Analysis, John Wiley and Sons, New Jersey.

24-478-0306: LIFETIME STUDIES IN DATA SCIENCE (INTEGRATED WITH R)

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand the basic concepts and ideas of survival analysis	Understand
2.	Examine the properties and methods for standard survival time distributions	Analysis
3.	Estimate survival functions using parametric and non-parametric methods	Evaluate
4.	Apply and interpret semi-parametric and parametric regression models for survival data	Apply
5.	Execute the methodologies using R	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	3	2		1
CO2	2	2	2	1	
CO3	2	3	1	1	
CO4	2	3	1	2	
CO5	2	3			

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Basic Quantities and Models - Survival function, Hazard function, Mean residual life function, Common Parametric Models for Survival Data; Censoring and Truncation - Right Censoring, Left or Interval Censoring, Truncation, Likelihood Construction for Censored and Truncated Data, Ageing

Module 2:

Some Parametric Families of Probability Distributions, Parametric Analysis of Survival Data, Non-parametric Estimation of Basic Quantities for Right Censored and Left Censored Data - Estimators of the Survival and Cumulative Hazard Functions for Right Censored Data, Pointwise Confidence Intervals for the Survival Function (without derivation), Estimators of the Survival Function for Left-Truncated and Right-Truncated Data; Estimation of the Survival Function for Left censored data.

Module 3:

Test for exponentiality, Two sample parametric problem.

Module 4:

Proportional Hazards Model: A Method of Regression- Coding Covariates, Partial Likelihoods for Distinct-Event Time Data, Partial Likelihoods when Ties are present, Model Building using the Proportional Hazards Model, Estimation for the Survival Function; Test for Constant of Proportionality in PH Model Analysis of Competing Risks, Repairable Systems

Reference Books:

1. J V Deshpande and Sudha Purohit (2005), Lifetime data: statistical models and Methods, World Scientific, Chapters 1-10.

Reference Books:

2. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag, New York.

3. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons, Relevant Sections of the Chapters 9.

4. Kalbfleisch J.D and Prentice. R.L. (2002) The Statistical Analysis of Failure Time Data, Second Edition, John Wiley & Sons Inc.

5. Hosmer Jr. D.W and Lemeshow S (1999) Applied Survival Analysis - Regression Modelling of Time to event Data, John Wiley & Sons. Inc.

6. Nelsrn. W (2003) Applied Life Data Analysis.

7. Miller, R.G. (1981) Survival Analysis, John Wiley.

24-478-0307: BAYESIAN COMPUTING AND ANALYSIS

After completion of this course the student should be able to:

	Course Outcome (CO)	Cognitive Level
1.	Understand basic concepts in Bayesian statistics including Bayes rule, prior, posterior distributions	Understand
2.	Describe different Bayesian models and its uses	Evaluate
3.	Explain different computation and simulation techniques in Bayesian statistics	Evaluate
4.	Apply Bayesian inference approaches to scientific and real-world problems	Apply

	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1			1
CO2	1	1	1		1
CO3	1	1	2		1
CO4			2		

1-Slightly/Low, 2-Moderate/Medium, 3-Substantial/High

Module 1:

Subjective notions of probability, Bayes Theorem and applications. Likelihood, Prior and posterior

Module 2:

Loss function, Bayes Rule, priors and other priors. Sensitivity Analysis, Posterior Convergence.

Module 3:

Bayesian Models: Poisson, Binomial, Univariate Gaussian, Multivariate Gaussian. Hierarchical Bayesian Model, Classification with Bayesian Logistic Regression, Discriminant Analysis.

Module 4:

Bayesian Computation and simulation techniques: (integrated with R Jags and Stan. Estimation of Posterior Mode with Optimization, Estimation of Posterior Mean and other summary with Monte Carlo Simulation, Accept-Rejection Sampling, Importance Sampling, Markov Chain and Monte Carlo, Metropolis-Hastings, Hamiltonial Monte Carlo

Reference Books:

1. James O. Berger (1985): Statistical Decision Theory and Bayesian Analysis, 2'nd Edition, Springer-Verlag New York.
2. Kruschke: (2014) Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and Stan, Academic Press.
3. Jim Albert: (2007) Bayesian Computation with R, Springer, New York.