Minor Degree in Mathematics & Computing:

Code	Course Title	L-T-P	Credits	Sem.
CD1M01	Elements of Computational Data Science	**3-0-0**	**3**	III
CD1M02	Introduction to Discrete Mathematical Structures	**3-0-0**	**3**	IV
CD1M03	Advanced Data Structures	**3-0-0**	**3**	V
CD1M04	Full Stack Development	**2-0-2**	**3**	VI
CD1M05	Mathematics for Machine Learning	**3-0-0**	**3**	VII

A student should complete a minimum of five courses (15 Credits) to get Minors degree.

CD1M01 **3-0-0 (3)**

Elements of Computational Data Science

Pre-Requisites: None

Course Outcomes:

CO1	Analyze the basics of data science
CO2	Apply Principal Component Analysis
CO3	Analyze spectral clustering
CO4	Compute dimension reduction and clustering of random graphs
CO5	Apply approximation algorithms

Syllabus:

Introduction and Algebra: Introduction of Data Science, Visualization of data, Resampling, Distributions, Linear Model & Bayesian Model, Simple examples, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation.

Statistics: Parameter Estimation, Bayesian Linear Regression, Maximum Likelihood as Orthogonal Projection, Principal Component Analysis (PCA), Spectral Clustering, Cheeger's inequality, Concentration of measure and tail bounds in probability. Dimension reduction through Johnson-Lindelstrauss Lemma and Gordon's Escape through a Mesh Theorem.

Graph Theory: Approximation algorithms in Theoretical Computer science and the Max-cut problem, Clustering of random graphs: Stochastic Block model, Synchronization, Inverse problems on graphs.

Optimization: Continuous Optimization, Basics of duality in Optimization, Convex Optimization.

Learning Resources:

Text Books:

1. **Joel Grus**, Data Science from scratch, O'Reilly Media, 2015.
2. **Murtaza Haider**, Getting Started with Data Science, IBM Press, 2016

Reference Books:

1. **Lillian Pierson**, Data Science for Dummies, Wiley, Second Edition, 2017.
2. **J Koponen & J Hidden**, Data Visualization Handbook, CRC Press, 2019.

CD1M02 **3-0-0 (3)**

Introduction to Discrete Mathematical Structures

Pre-Requisites: None

Course Outcomes:

CO1	Apply Propositional and first-order logic to determine the statement's validity
CO2	Construct induction proofs involving summations, inequalities, and divisibility
CO3	Implement principles of counting, permutations, and combinatory to solve real-world problems. Formulate and solve recurrence relations
CO4	Determine whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram.
CO5	Develop and analyse the concepts of Boolean algebra

Syllabus:

Mathematical Logic: Connectives, Tautologies, the equivalence of formulas, duality law, tautological implications, normal forms, theory of inference for statement calculus, methods of proof, predicative logic, statement functions, variables, and quantifiers, free and bound variables, and inference theory for predicate calculus.

Counting: Basics of counting, Permutations, and combinations - Generalized Permutations and combinations – Pascal's Identity- Vandermonde's Identity, the Principles of Inclusion–Exclusion, Pigeonhole Principle, and Application.

Recurrence relations: Generating functions, Generating Functions of Permutations and Combinations, Formulation as Recurrence Relations, Solving Recurrence Relations by Substitution and Generating Functions, Method of Characteristic Roots, Solving Inhomogeneous Recurrence Relations – Applications of recurrence relations.

Relations: Binary relations - Properties of binary relations, equivalence relations and partitions, Matrix Representation of relations, Adjacency Matrices, Incidence Matrices, Transitive closure and Warshal's algorithm, Partial and total ordering relations.

Boolean Algebra: Chains, Lattices, the principle of duality, basic properties of lattices, distributive and complemented lattices, Boolean lattices and algebras, uniqueness of finite Boolean algebras, Boolean expressions, and functions - Representation and Minimizations of Boolean functions.

Learning Resources:

Text Books:

1. **J. R. Mott, A. Kandel and Baker**, Discrete Mathematics for Computer Scientists, PHI, 2006, Third Edition.
2. **C.L. Liu**, Elements of Discrete Mathematics, McGraw Hill, 2017, Fourth Edition.

Reference Books:

1. **J. P. Tremblay and R. Manohar**, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co., 2017.
2. **Bernand Kolman, Robert C. Busby, Sharon Cutler Ross**, Discrete Mathematical Structures, PHI, 2008, Sixth Edition.

CD1M03 **3-0-0 (3)**

Advanced Data Structures

Pre-Requisites: None

Course Outcomes:

CO1	Understand and implementation of symbol table using hashing techniques
CO2	Apply the concept of Skip Lists for Data Structures and Algorithms.
CO3	Develop and analyze algorithms for red-black trees, B-trees and Splay trees
CO4	Develop algorithms for text processing applications
CO5	Identity suitable data structures and develop algorithms for computational geometry

Syllabus:

Dictionaries: Definition, Dictionary Abstract Data Type, Implementation of Dictionaries.

Hashing: Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic Probing, Double Hashing, Rehashing, Extendible Hashing.

Skip Lists: Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists

Trees: Binary Search Trees (BST), AVL Trees

Red Black Trees: Height of a Red Black Tree, Red Black Trees Bottom-Up Insertion, Top-Down Red Black Trees, Top-Down Deletion in Red Black Trees, Analysis of Operations.

2-3 Trees: Advantage of 2-3 trees over Binary Search Trees, Search and Update Operations on 2-3 Trees, Analysis of Operations.

B-Trees: Advantage of B- trees over BSTs, Height of B-Tree, Search and Update Operations on 2-3 Trees, Analysis of Operations.

Splay Trees: Splaying, Search and Update Operations on Splay Trees, Amortized Analysis of Splaying.

Text Processing: String Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem.

Computational Geometry: One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees.

Learning Resources:

Text Books:

1. **Mark Allen Weiss**, "Data Structures and Algorithm Analysis in C++", 2nd Edition, Pearson, 2004.

Reference Books:

1. **Michael T. Goodrich, Roberto Tamassia**, "Algorithm Design", 1st Edition, Wiley, 2006.

CD1M04 **2-0-2 (3)**

Full Stack Development

Pre-Requisites: None

Course Outcomes:

CO1	Understand, analyze and build dynamic and interactive web sites.
CO2	Understand current and evolving Web languages for integrating media and user interaction in both front end and back end elements of a Web site.
CO3	Analysis and reporting of web data using web analytics.
CO4	Applying different testing and debugging techniques and analyzing the web site effectiveness.

Syllabus:

HTML: Introduction to HTML, What is HTML, HTML Documents, Basic structure of an HTML document, creating an HTML document, Mark up Tags, Heading-Paragraphs, Line Breaks, HTML Tags. Elements of HTML: Introduction to elements of HTML, Working with Text, Working with Lists, Tables and Frames, Working with Hyperlinks, Images and Multimedia, Working with Forms and controls.

Java Script: Introduction to JavaScript, Basic Syntax, Control Structures, Writing Functions, Working with Arrays, The Document Object Model, Events Handling, Client-side Validation, Form Validation & RegExps, ASP, Perl CGI, & Form Methods, SSI & Cookies, Frames & Windows, mimeTypes, plugins, & Java.

PHP: PHP installation and Introduction, Loops String Functions in PHP, PHP Email Function, PHP Basics, Variables Arrays in PHP with Attributes Date & Time, Image, Uploading File handling in PHP Functions in PHP, Errors handling in PHP.

Python: Introduction to Python, Python basics, Data Types and variables Operators, Looping & Control Structure List, Modules Dictionaries, String Regular Expressions, Functions and Functional Programming, Object Oriented Linux Scripting Environment – Classes, Objects and OOPS concepts, File and Directory Access, Permissions and Controls Socket, Libraries and Functionality Programming, Servers and Clients Web Servers and Client scripting, Exploit Development techniques, Writing plugins in Python, Exploit analysis, Automation Process, Debugging basics, Task Automation with Python

Application using Node JS and MongoDB: Introduction to Node.js; Events; Streams; Modules; Express; Socket.io; Persisting Data. Introduction to MongoDB, Accessing MongoDB from Node JS.

Learning Resources:

Text Books:

1. **Deitel, Deitel and Nieto**, "Internet and Worldwide Web - How to Program", 5th Edition, PHI, 2011.
2. **Bai and Ekedhi**, "The Web Warrior Guide to Web Programming", 3rd Edition, Thomson, 2008.

Reference Books:

1. **Brad Dayley, Brendan Dayley, and Caleb Dayley** , Node.Js, Mongodb and Angular Web Development: The Definitive Guide to Using the Mean Stack to Build Web Applications, 2nd Edition, –Pearson Education, 2018
2. **Robertw. Sebesta**, Programming World Wide Web, 8th Edition –Pearson Education, 2020.

CD1M05 **3-0-0 (3)**

Mathematics for Machine Learning

Pre-Requisites: None

Course Outcomes:

CO1	Improve the skills and knowledge in linear algebra and matrix theory to get more out of machine learning
CO2	Understand the matrix decomposition and dimension reduction algorithms required to build many common machine learning techniques
CO3	Learn the calculus to build machine learning applications
CO4	Learn the basic theoretical properties of optimization problems, for applications in machine learning
CO5	Understand the support vector algorithms required to build many common machine learning techniques

Syllabus:

Linear Algebra Basics: Vector spaces and subspaces, basis and dimensions, linear transformation, four fundamental subspaces.

Matrix Theory- Norms and spaces, eigenvalues and eigenvectors, Special Matrices and their properties, least squared and minimum normed solutions.

Matrix Decomposition Algorithms- SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition.

Dimensions Reduction Algorithms and JCF: Principal component analysis, linear discriminant analysis, minimal polynomial and Jordan canonical form.

Calculus: Basic concepts of calculus: partial derivatives, gradient, directional derivatives, jacobian, hessian, convex sets, convex functions and its properties.

Optimization: Unconstrained and Constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, Steepest descent method, Penalty function method.

Support Vector Machines: Introduction to SVM, Error minimizing LPP, concepts of duality, hard and soft margin classifiers.

Learning Resources:

Text Books:

1. **W. Cheney**, Analysis for Applied Mathematics. New York: Springer Science+Business Medias, 2001.
2. **S. Axler**, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.

Reference Books:

1. **J. Nocedal and S. J. Wright**, Numerical Optimization. New York: Springer Science+Business Media, 2006.
2. **J. S. Rosenthal**, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.