Course Title	**Data Structures and Algorithms**
Course Code	**CC-213**
Credit Hours	3
Category	Computing core
Prerequisite	CC-211: Object Oriented Programming
Co-Requisite	None
Follow-up	CC-311: Operating Systems, DI-326: Artificial Intelligence
Course Description	**Algorithm Specification:** Properties of Algorithm, examples, performance, complexity analysis, measurement, and Big Oh notation. **Abstract data types (ADTs):** Array and Polynomial as an ADT, Sparse Matrices, and Representation of Arrays. **Stack ADT:** Linked lists and array implementations, Expressions, Postfix Notation, and Infix to postfix conversion. **Recursion:** Recursive Definition and Processes, Writing Recursive Programs, analyzing recursive algorithms. **Queue:** The Queue ADT, Linked and array implementations of queues, circular and double ended queue, dequeuer, priority queues. **Self-Referencing Classes**: Dynamic Memory Allocation, garbage collection. **Linked List:** Singly Linked Lists, Circular Lists, Linked Stacks and Queues (Double Ended List), Doubly Linked Lists. **Trees:** Introduction to Trees, Logical construction and traversing of Binary Trees, Implementation of Binary Trees (Insertion and Traversing), Searching and deletion in Binary Trees, Binary Search Tree, Introduction to Balanced and AVL Trees. **Heaps:** Heaps and Heaps as Priority Queues, Double Ended Priority Queue. **Searching:** Linear Search, Binary Search, and Types of Indexing. **Hashing:** Hash Functions, Division, Overflow Handling, Chaining. **B-Trees**, **Generalized List**, etc. **Divide and conquer algorithms**. **Sorting:** selection, insertion, merge, quick, bubble, heap, shell, radix, bucket. **Graphs:** Graph terminology, Adjacency List and Adjacency Matrix and Adjacency list representation of Graph. **Elementary Graph Operations:** Breadth First Search and Depth First Search, Spanning Trees (BFSST, DFSST), topological order, shortest path.
Text Book(s)	1. Ellis Horowitz, Sartaj Sahni, D. Mehta, Fundamentals of Data Structures in C++, 2nd Ed., Computer Science Press, 1995. ISBN 81-7808-792-8. 2. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Ed., Cengage Learning, ISBN 978-1133608424.
Reference Material	1. D. Samanta, Classic Data Structures, Prentice Hall, 2001, ISBN: 812033731X. 2. Mark Allen Weiss, Data Structure and Algorithms in C++, 3rd Ed., Pearson Education, 2006, ISBN: 978-0321441461. 3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, 2nd Ed, MIT Press, 2001, ISBN 0-07-013151-1. 4. Reference from different books enlisted in reference material will be given as required or lecture notes for reading will be provided.

Course Title	**Data Structures and Algorithms Lab**
Course Code	**CC-213L**
Credit Hours	1
Category	Computing core
Prerequisite	CC-211: Object Oriented Programming
Co-Requisite	None
Follow-up	CC-311: Operating Systems, DI-326: Artificial Intelligence
Course Description	**Implementation**: the concepts studied in "CC-213 Data Structures and Algorithms", Performance Analysis/Measurement, Sparse Matrices, N-Dimensional Arrays. **Stack**: Expressions Evaluation. **Recursion**: Backtracking. **Queue**: Double Ended Queue, Self-Referencing Classes and Dynamic Memory Allocation. **Linked List**: Singly Linked Lists, Circular Lists, Linked Stacks and Queues (Double Ended List), Doubly Linked Lists. **Trees:** Binary Trees, Binary Search Tree, Introduction to Height Balanced and AVL Trees, Heaps and Heaps as Priority Queues, Double Ended Priority Queue. **Searching:** Linear Search, Binary Search, and Types of Indexing. **Hashing:** Hash Functions, Collision Resolution: Open Hashing, Chaining. **Sorting:** Logical and Algorithmic Implementation of Selection, Bubble, Insertion, Shell, Radix, Merge, Quick, Heap Sort. **Graphs:** Graph terminology, Adjacency List and Adjacency Matrix and Adjacency list representation of Graph. **Elementary Graph Operations:** Breadth First Search and Depth First Search, Spanning Trees (BFSST, DFSST).
Text Book(s)	1. Ellis Horowitz, Sartaj Sahni, D. Mehta, Fundamentals of Data Structures in C++, 2nd Ed., Computer Science Press, 1995. ISBN 81-7808-792-8.
Reference Material	1. D. Samanta, Classic Data Structures, Prentice Hall, 2001, ISBN: 812033731X. 2. Mark Allen Weiss, Data Structure and Algorithms in C++, 3rd Ed., Pearson Education, 2006, ISBN: 978-0321441461. 3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, 2nd Ed, MIT Press, 2001, ISBN 0-07-013151-1.

Course Title	**Database Systems**
Course Code	**CC-215**
Credit Hours	3+1
Category	Computing Core
Prerequisite	None
Co-Requisite	None
Follow-up	DI-324: Database Administration and Management
Course Description	**File Systems and Databases:** Introduction, A File system Critique, Database Systems, Database approach vs file-based system, database architecture, three level schema architecture, data independence, Database Models. **Introduction to RDBMS:** Logical view of Data; Entities and Attributes, Tables and their Characteristics, Keys; relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints. **Relational Algebra:** Relational Database Operators, selection, projection, Cartesian product, types of joins. **Entity Relationship (E-R) Modeling:** Basic Modeling Concepts, entity sets, attributes, relationship, entity-relationship diagrams, **Normalization of Database Tables:** Objectives, Forms, Normalization and Database Design, functional dependencies, normal forms, Denormalization, **Structured Query Language (SQL):** Introduction, DDL Commands, Joins and subqueries in SQL, Grouping and aggregation in SQL, DML Commands, DCL Commands, Complex Queries and SQL Functions, Procedural SQL; Triggers, Stored procedures. **Database Design:** The System Development Life Cycle (SDLC), The Database Life Cycle (DBLC), Database Design Strategies, **Transaction Management and Concurrency Control:** Introduction, Transaction Properties and Types, Concurrency Control Issues, Database Recovery Management. **DDBMS:** Evolution, Components, Distributed processing and distributed databases, Distributed database transparency features. Distributed database design, Data fragmentation, Data replication, NoSQL systems.
Text Book(s)	1. Carlos Coronel, Steven Morris, Database Systems: Design, Implementation & Management, 13th Edition, Cengage Learning, 2017. ISBN-10: 1337627909.
Reference Material	1. Jeffrey A. Hoffer, Ramesh Venkataraman, Heikki Topi, Modern Database Management, 12th Edition, Pearson, 2015. ISBN-10: 0133544613. 2. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015. ISBN-10: 1292061189. 3. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2016. ISBN-10: 1292097612. 4. C. J. Date, An Introduction to Database Systems, 8th Edition, Pearson, 2004. ISBN-10: 0321189566. 5. Michael McLaughlin, Oracle Database 11g PL/SQL Programming, 1st Edition, McGraw-Hill Education, 2008, ISBN: 0071494456.

Course Title	**Database Systems Lab**
Course Code	**CC-215L**
Credit Hours	1
Category	Computing Core
Prerequisite	None
Co-Requisite	None
Follow-up	DI-324: Database Administration and Management
Course Description	**Introduction to SQL environment:** Writing Basic SQL Statements; SELECT Statement, Arithmetic Expressions, Operator Precedence, Null Value, Column Alias, Concatenation Operator, Display table Structure. **From Clause:** Table list, Table Alias. Restricting and Sorting Data; WHERE Clause, Comparison operators, Logical operators, ORDER BY clause **Where Clause:** Conditions, logical operators and their precedence**,** order by clause. **Single row functions:** character functions, number functions, date functions, type conversion functions. **Multi row Functions**: Sum, Average, Standard deviation, Variance, Subgrouping of data, Group by Clause, use of Having clause. **Join:** Cross product, natural join, Equi-join, Non equi-join, left outer-join, right outer-join, self-join. **Subquery:** use of subquery, subquery syntax, Multiple Column Subqueries, pairwise comparison, Non-pair wise comparison, Null Value in a subquery, Subquery in From Clause. **Creating and Altering SQL tables**: Create table statement, Defining Constraints, Column Level and Table Level, NOT NULL Constraint, UNIQUE Key Constraint, PRIMARY Key Constraint, FOREIGN Key Constraint, CHECK Constraint, Alter table statement, drop statement, **Data Manipulation:** Insert, Update, Delete statements. **SQL Objects:** Views, Sequences, Indexes. **User Management:** Create user, user privileges, user groups, Grant, Revoke statements.
Text Book(s)	1. Michael McLaughlin, Oracle Database 11g PL/SQL Programming, 1st Edition, McGraw-Hill Education, 2008, ISBN: 0071494456.
Reference Material	1. Jeffrey A. Hoffer, Ramesh Venkataraman, Heikki Topi, Modern Database Management, 12th Edition, Pearson, 2015. ISBN-10: 0133544613. 2. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015. ISBN-10: 1292061189.

Course Title	**Software Engineering**
Course Code	**CC-212**
Credit Hours	3
Category	Computing Core
Prerequisite	None
Co-Requisite	None
Follow Up	None
Course Description	**Introduction:** Nature of Software, Overview of Software Engineering, Professional software development, Software engineering practice, Software process structure, **Software Process Models:** Waterfall Model, Incremental Model, Prototyping Model, Spiral Model, RAD Model. **Agile Software Development:** Agile process models, Agile development techniques. Introduction to Project Management, Introduction to Requirements Engineering, Functional and non-functional requirements. **Analysis Model:** Context models, Interaction models, Structural models, behavioral models, model driven engineering, Data modeling, Functional Modeling, Behavioral Modeling. **Software Design:** Data Design, Architectural Design, Component Level Design, User Interface Design**. Object Oriented Analysis & Design Basics:** Introduction to UML, UML Diagrams. Use Case Modeling, Rational Rose overview, Use case modeling in Rational Rose. **Domain Model:** Identifying business classes, Domain Model Associations, Domain Model Attributes, Implementation of Sequence Diagram and Domain model in Rational Rose. **Interaction Diagram:** Sequence diagrams, Collaboration Diagrams, Implementation of Sequence and Collaboration diagrams in Rational Rose. **Design Class Diagram,** Mapping Design to Code. **Software Testing Fundamentals**. Design patterns, Software testing and quality assurance. Software evolution. **Project Management**: Project planning, configuration management. **Software Process improvement**.
Text Book(s)	1. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2015, ISBN-13: 978-0133943030.
Reference Material	1. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson, 2002, ISBN-13: 978-0133056990.

5. INFORMATION TECHNOLOGY DOMAIN SUPPORTING COURSES

Course Title	**Modeling and Simulation**
Course Code	**SI-241**
Credit Hours	3
Category	IT Supporting
Prerequisite	None
Co-Requisite	None
Follow-up	None
Course Description	**Introduction to modeling and simulation**: System analysis, Classification of systems, System theory basics and its relation to simulation. **Classification of models:** Model classification at various levels including conceptual, abstract, and simulation. **Model building:** Methodology of model building, Means for model and experiment description, Principles of simulation system design, Simulation systems and languages. **Widely used modeling systems:** Models of queuing systems, Discrete simulation models, Simulation experiment control, Overview of numerical methods used for continuous simulation. **Models of heterogeneous systems**: Simulation using automata, **Verification and validation of models:** Requirements verification, Design Verification, Code verification, Predictive validation, Parameter Variability/ Sensitivity analysis, analysis of simulation results, visualization of simulation results, Model optimization. **Pseudorandom numbers:** generation and transformation of random numbers with overview of commonly used simulation systems.
Text Book(s)	1. Modeling and Simulation, Bungartz, H.-J., Zimmer, S., Buchholz, M., Pflüger, D., Springer-Verlag, 2014. 2. Simulation Modeling Handbook, A Practical Approach, Christopher A. Chung, CRC Press, 2004. 3. System design, modeling and simulation using Ptolemy II, Claudius Ptolemaeus, , Ver 2.0, Creative Commons Attribution-ShareAlike 3.0 Unported, 2014.
Reference Material	1. Applied Simulation Modeling, Andrew F. Seila, Vlatko Ceric, Pandu Tadikamalla, Thomson Learning Inc., 2003.

Course Title	**Linear Algebra**
Course Code	**MS-252**
Credit Hours	3
Category	Math & Science Foundation
Prerequisite	None
Co-Requisite	None
Follow-up	None
Course Description	**Linear Equations in Linear Algebra:** Systems of Linear Equations, Row Reduction and Echelon Forms, Vector Equations, The Matrix Equation Ax = b, Solution Sets of Linear Systems, Applications of Linear Systems, Linear Independence, Introduction to Linear Transformations, The Matrix of a Linear Transformation, Linear Models in Business, Science, and Engineering. **Matrix Algebra:** Matrix Operations, The Inverse of a Matrix, Characterizations of Invertible Matrices, Partitioned Matrices, Matrix Factorizations, Applications to Computer Graphics, Subspaces of R^n, Dimension and Rank. **Determinants:** Introduction to Determinants, Properties of Determinants, Cramer's Rule, Volume, and Linear Transformations. Vector Spaces: Vector Spaces and Subspaces, Null Spaces, Column Spaces, and Linear Transformations, Linearly Independent Sets; Bases, Coordinate Systems, The Dimension of a Vector Space, Rank, Change of Basis. **Eigenvalues and Eigenvectors:** Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization, Eigenvectors and Linear Transformations, Complex Eigenvalues, Discrete Dynamical Systems. **Orthogonality and Least Squares:** Inner Product, Length, and Orthogonality, Orthogonal Sets, Orthogonal Projections, The Gram–Schmidt Process, Least-Squares Problems, Applications to Linear Models, Inner Product Spaces, Applications of Inner Product Spaces. **Symmetric Matrices and Quadratic Forms:** Diagonalization of Symmetric Matrices, Quadratic Forms, Constrained Optimization, The Singular Value Decomposition, Applications to Image Processing and Statistics. **The Geometry of Vector Spaces:** Affine Combinations, Affine Independence, Convex Combinations, Hyperplanes. **Optimization:** Matrix Games, Linear Programming—Geometric Method, Linear Programming—Simplex Method, Duality.
Text Book(s)	1. David C. Lay, Steven R. Lay, Judi J. McDonald, Linear Algebra and Its Applications, 5th Edition, Pearson, 2015, ISBN-13: 978-0321982384, ISBN-10: 032198238X. 2. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016, ISBN-13: 978-0980232776, ISBN-10: 0980232775. 3. Howard Anton, Elementary Linear Algebra, 11th Edition, Wiley, 2013, ISBN-13: 978-0470458211, ISBN-10: 0470458216.
Reference Material	1. Philip N. Klein, Coding the Matrix: Linear Algebra through Applications to Computer Science, 1st Edition, Newtonian Press, 2013, ISBN-13: 978-0615880990, ISBN-10: 0615880991. 2. David Hill, David Zitarelli, Linear Algebra Labs with MATLAB, 3rd Edition, Pearson, 2003, ISBN-13: 978-0131432741, ISBN-10: 0131432745.