# UNIVERSITY OF DELHI

## B.Tech. (Information Technology & Mathematical Innovations)

## (Cluster Innovation Centre)

**(SEMESTER-I)**
based on

Undergraduate Curriculum Framework 2022 (UGCF)

(Effective from Academic Year 2022-23)

University of Delhi

**Semester –I**

**DSCs:-**

| Course Title | Nature of the Course | Total Credits | Components | | | Eligibility Criteria/ Prerequisite | Contents of the course and references may be seen at |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| Single and Multivariable Calculus | DSC-1 | 4 | 3 | 0 | 1 | Mathematics till Class XII | Annexure – I |
| Discrete Mathematics | DSC-2 | 4 | 3 | 1 | 0 | Mathematics till Class XII | Annexure -II |
| Programming Fundamentals | DSC-3 | 4 | 3 | 0 | 1 | Mathematics till Class XII | Annexure -III |

**GEs:-**

| Course Title | Nature of the Course | Total Credits | Components | | | Eligibility Criteria/ Prerequisite | Contents of the course and references may be seen at |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| Engineering Physics I | GE1.1 | 4 | 2 | 0 | 2 | Science till Class X | Annexure – IV |
| Engineering Chemistry - I | GE1.2 | 4 | 2 | 0 | 2 | Science till Class X | Annexure –V |

## B. Tech. (IT & Mathematical Innovations)

### COURSE STRUCTURE

**Key: L: Lecture, T: Tutorial, P: Project/Practical**

Semester I

| PS. No. | Course Title | Course Code | Credits | | | | Prerequisite of the course |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | Total | |
| 1 | Single and Multivariable Calculus | DSC 01 | 3 | - | 1 | 4 | Mathematics Till Class XII |
| 2 | Discrete Mathematics | DSC 02 | 3 | 1 | - | 4 | Mathematics Till Class XII |
| 3 | Programming Fundamentals | DSC 03 | 3 | - | 1 | 4 | Mathematics Till Class XII |
| 4 | Engineering Physics I OR | GE 01 | 2 | - | 2 | 4 | Science Till Class X |
| | Engineering Chemistry I | | 2 | - | 2 | | Science Till Class X |
| 5 | Choose one from a pool of AEC | AEC 01 | | | | 2 | |
| 6 | Choose one from a pool of VAC | VAC 01 | | | | 2 | |
| 7 | Choose one from a pool of SEC | SEC 01 | | | | 2 | |
| Grand Total | | | | | | 22 | |

## B. Tech. (IT & Mathematical Innovations)

### COURSE CONTENT

**SEMESTER – I**

**DSC 1: Single and Multivariable Calculus [Theory + Practical] [Semester I] [3 – 0 – 1]**

**Course Objective:** Calculus is the most powerful tool in mathematics with widespread applications. The goal of this course is for students to gain proficiency in calculus computation. The course builds up on the topics, namely limits and continuity, differentiation and integration. These topics will use to solve application problem in a variety of fields such as physics, biology, business and economics.

**Keywords:** Calculus; Limits and continuity, differentiation and integration; Sequences and Series

**Unit I:** *Limits and continuity*
Limits at infinity - Indeterminate forms - Special limits involving exponential and logarithmic functions – Asymptotes - Graphs of function and its derivatives - Optimization problems - Fluency in differentiation - Concavity and inflexion points - Sequences, infinite series including Taylor approximations, Power series **(12 lectures)**

**Unit II:** *Integration*
Parametric equations of curves, arc length and surface area - Vector valued functions, differentiation and integration of vector valued functions **(9 lectures)**

**Unit III:** *Functions of several variables*
Level curves and surfaces - Limits and continuity of functions of two and three real variables - Partial differentiation (two variables), partial derivative as a slope, partial derivative as a rate, Maxima and Minima **(12 lectures)**

**Unit IV:** *Multiple Integrals*
Line, surface and volume integrals - Applications of Green's, Stokes and Gauss's Theorem. **(9 lectures)**

**Engineering Kitchen Activity (Symbolic Mathematics Software) [Laboratory]**

- Introduction of basic functions
- Plotting of graphs of functions and their derivatives
- Manipulating the parameters in a graph
- Fitting of a curve
- Parametric plot of curves (Eg. Trochoid, Cycloid, Epicycloid)
- Obtaining surfaces of revolution of curves
- Plotting functions of two variables and their level curves
- Graphical illustration of limits for functions of two variables
- Innovation Project

**Course Learning Outcomes:**

- A good understanding of basic concepts of limits, derivatives, continuity, asymptotes, sequence and series, integrals, vector valued functions, partial differentiation, multiple integrals, etc.
- Able to find points of discontinuity for functions and classify them and understand the consequences of the intermediate value theorem for continuous functions.
- Able to solve applied problems using basic concepts of calculus.
- Able to explain why calculus is valuable in daily life.
- Create a project using the fundamental knowledge and principle of differential and integral calculus that helps to provide a hands-on experience of the same.

- Able to plot and manipulate the curves appropriately to make various real life models like studying the projectile motion in firecrackers and the flow of water in fountain.
- Create animations of given problems using MATHEMATICA software.

Teaching Plan (**Theory**)

| | |
|---|---|
| **Week 1:** | Limits and continuity; Limits at infinity; Indeterminate forms; Special limits involving exponential and logarithmic functions |
| **Week 2:** | Asymptotes; Concavity and inflexion points; Graphs of function and its derivatives |
| **Week 3:** | Sequences, Infinite series including Taylor approximations |
| **Week 4:** | Power series |
| **Week 5:** | Integration; Parametric equations of curves, arc length |
| **Week 6:** | Volume and Surface area |
| **Week 7:** | Vector valued functions, differentiation and integration of vector valued functions |
| **Week 8:** | Functions of several variables; Level curves and surfaces; Limits and continuity of functions of two and three real variables |
| **Week 9:** | Partial differentiation (two variables) |
| **Week 10:** | Partial derivative as a slope; Partial derivative as a rate |
| **Week 11:** | Maxima and Minima |
| **Week 12 and 13:** | Multiple Integrals, line, surface and volume integrals |
| **Week 14:** | Applications of Green's, Stokes and Gauss's Theorem |

**References**


1. *Calculus*, T. M. Apostol, Volumes 1 and 2, Wiley Eastern, 1980.
2. *Calculus - Single and Multivariable*, Hughes-Hallett et al., John-Wiley and Sons, 2003.
3. *Calculus*, James Stewart, Thomson, 2003.
4. *Calculus and Analytic Geometry*, G. B. Thomas and R. L. Finney, Addison-Wesley, 1998.


**DSC 2: Discrete Mathematics and its Applications [Theory] [Semester I] [3 – 1 – 0]**

**Course Objective:** The objective of this paper is to familiarize the student with basic concepts of logic and combinatorics. The aim of the paper is also to conceptualize the terminologies of graph theory, isomorphism, paths, cycles, circuits, graph coloring in various physical situations. Throughout this paper, students will be encouraged to develop their own algorithms and to analyze their computational complexities. Further, students may develop codes in any of the programming language for implementation of various algorithms.

**Keywords:** Logic; Combinatorics; Graph theory; Trees

**Unit I:** *Logic and Combinatorics*
Propositional Logic; Truth tables; Conditional statements; Logic and Bit operations; Propositional and logical equivalences; De Morgan's law; Applications of propositional logic. Sets, counting of sets - Permutation - Combination - Inclusion - exclusion - Generating functions - Recurrence relations **(12 lectures)**

**Unit II:** ***Graph Theory***
Introduction - Basic terminologies - Graph representation - Euler relation Isomorphism - Connectivity - Cut vertices and edges - Covering - Euler and Hamilton paths and circuits **(12 lectures)**

**Unit III:** ***Applications of Graph Theory***
Shortest Path Algorithms: Dijkstra's algorithm -Travelling salesman problem - Scheduling problems - Matching - Independent sets - Coloring - ***Planar graph:*** idea of region - Euler formula - Kuratowski theorem and application **(9 lectures)**

**Unit IV:** ***Tree***

Basic terminology, traversal, Prefix code - Idea of data compression: Huffman code - Spanning tree - Minimum spanning tree: Prim's and Kruskal method. **(9 lectures)**

**Course Learning Outcomes:** After completing this course, student should be able to;

- Familarize with basic concepts of logic
- Understand combinatorics principles: sets, permutations, combinations, recurrence relations etc.
- Conceptualize basic terminologies of graph theory, isomorphism, connectivity etc
- Understand concepts of paths, cycles, circuits and their applications in various fields
- Learn different shortest path algorithms, their computational complexities, implementation & programming
- Understand travelling salesman problem and its importance
- Understand the concept of graph coloring with real applications, planar graphs and algorithms
- Conceptualize trees, spanning trees and algorithms

Teaching Plan (**Theory**)

| | |
|---|---|
| **Week 1 and 2** | Propositional Logic; Truth tables; Conditional statements; Logic and Bit operations; Propositional and logical equivalences; De Morgan's law; Applications of propositional logic |
| **Week 3:** | Sets, counting of sets; Permutation; Combination; Inclusion and exclusion principles; Generating functions; Recurrence relations |
| **Week 4:** | Introduction to Graph theory; Basic terminologies |
| **Week 5:** | Graph representation; Euler relation |
| **Week 6:** | Isomorphism; Connectivity; Cut vertices and edges; Covering |
| **Week 7:** | Euler and Hamilton paths and circuits |
| **Week 8:** | Shortest Path Algorithms: Dijkstra's algorithm |
| **Week 9:** | Travelling salesman problem |
| **Week 10:** | Scheduling problems - Matching - Independent sets - Coloring |
| **Week 11:** | Idea of region in a planar graph; Euler formula; Kuratowski theorem and application |
| **Week 12:** | Basic terminologies of a Tree; Traversal; Prefix code |
| **Week 13:** | Idea of data compression: Huffman code |
| **Week 14:** | Spanning tree - Minimum spanning tree; Prim's and Kruskal method. |

**References:**

1. *Discrete and Combinatorial Mathematics,* Ralph Grimaldi, International Edition, 2003.
2. *Discrete Mathematical Structures,* Bernard Kolman, Robert Busby, Sharon Ross, International Edition, 2008.
3. *Discrete Mathematics and Its Applications,* K. H. Rosen, McGraw-Hill, 2008.

**DSC 3: Programming Fundamentals [Theory + Practical] [Semester I] [3 – 0 – 1]**

**Course Objectives:** This course aims at providing the fundamental knowledge of programming. This course trains students to design code, write programs to instruct computer systems. In addition, the course objective is to give an understanding of real-world data, tasks and their representation in terms of programs.

**Keywords:** Algorithm; Programming; Coding

**Unit I:** ***Philosophy of programming and algorithm***
Algorithm and its characteristics-Programming philosophy-Problem solving process-Programming language concepts-Program life cycle **(9 lectures)**

**Unit II:** ***Data representation and storage***
Data definition structures such as types-constants-variables-Expressions such as arithmetic-logical-Precedence and associative rules-Control Structures-Functions-Variable scope **(12 lectures)**

**Unit III:** *Multiple data item and processing*
Preprocessing - Arrays, Structures – Strings - Pointers - Memory allocation **(12 lectures)**

**Unit IV:** *Permanent storage and information handling*
Files handling – Coding guidelines - testing & debugging-System testing & Integration **(9 lectures)**

**Engineering Kitchen Activity [Laboratory]**

- User input and output programs having mathematical operations
- Pattern printing programs
- Programs for operators implementation
- Programs to implement function
- Programs to implement collection such as Array and String
- Programs to implement structure
- Innovation Project

**Course Learning Outcomes:** Following are the Course Learning Outcomes which students will have at the end of the course.

- Will have understanding of Programming Concepts
- Will have understanding of real world applications development through programs
- Will have understanding of independent data and collection of data and their organization
- Will have understanding of memory allocation on runtime
- Will understanding the program life cycle
- Will have understanding of testing, coding guidelines, debugging and integration.

Teaching Plan **(Theory)**

| | |
|---|---|
| **Week 1:** | Algorithm and its characteristics, Programming philosophy |
| **Week 2:** | Problem solving process, programming language concepts |
| **Week 3:** | Program life cycle |
| **Week 4:** | Data definition structures such as types-constants-variables |
| **Week 5:** | Operators implementation, expressions such as arithmetic, logical |
| **Week 6:** | Control structures, Precedence and associative rules |
| **Week 7:** | Functions, Variable scope |
| **Week 8:** | Pointers |
| **Week 9:** | Memory allocation, Preprocessing |
| **Week 10:** | Arrays, Strings |
| **Week 11:** | Structures |
| **Week 12:** | Files handling |
| **Week13 and 14:** | Coding guidelines, Unit testing & debugging, System testing & Integration |

**References:**


1. *C++: The Complete Reference, Fourth Edition*, Herbertz Schildt, McGraw Hill, 2015.
2. *The C++ Programming Language, 4th Edition*, Bjarne Stroustrup, Addison-Wesley, 2013.
3. *Computer Science: A Structured Approach Using C++ 2nd Edition*, Behrouz A. Forouzan, Richard F. Gilberg, 2004
4. *The C Programming Language (Ansi C Version)*, Brian W. Kernighan, Dennis M. Ritchie, 1990.

**NOTE: The core papers offered in the B.Tech. Course at CIC are Mathematics and Information Technology. Therefore, the students will choose GE offered by Physics and Chemistry faculty members.**

**GE 1.1. Engineering Physics I [Theory + Practical] [Semester I] [2 – 0 – 2]**
**(To be offered by Physics faculty members)**

**Course Objective:** This interactive learning module intends to provide basic theoretical understanding of Classical Mechanics with special emphasis on learning how these theoretical concepts are applied in designing mechanical and energy efficient systems etc.

**Keywords:** Classical Mechanics; Central force motion; Machines; Energy

**Unit I:** ***Classical mechanics at work***
Newtonian Mechanics (Kinematics & Dynamics) - Classical Mechanics at work - deconstructing mechanical systems - Universal Gravitation **(12 lectures)**

**Unit II:** ***Oscillation & Rotation***
Oscillations - Inertial & Non-inertial frames - Central force motion - Understanding rotational dynamics **(12 lectures)**

**Unit III:** ***Machines***
Efficiency and mechanical advantage in simple and complex machines: Levers, Pulley, Wheel & Axles, Gear systems, Hydraulic systems **(12 lectures)**

**Unit IV:** ***Energy Applications***
Forms of energy and conversion between different forms of energy. **(6 lectures)**

**Engineering Kitchen Activities [Laboratory]**

- Concepts of measurement, error, precision, accuracy. Concept of scale. Understanding Measuring Instruments
- Understanding oscillation using simple and compound pendulums
- Mechanics system with 850 Universal Interface – understanding Newtonian Dynamics
- Measurement of Moment of inertia from rotational dynamics
- Roller coaster dynamics – computer simulation and physical verification
- Coupled pendulum motion – using webcam and image analysis
- Ballistic Pendulum
- Understanding physics of complex machines – one implementation of "Tod-Phod-Jod" concept.
- Visualization in 3D and understand how things work – Building a CAD model in 3D to trace the flow of power, energy, information and material.
- Innovation project – designing instruments, machines, prototypes, applets

**Course Learning Outcomes:**

- Understanding of physics principles in machines.
- Ability to conceptualize and build machines for real life use.
- Reverse engineering of mechanical devices and redesigning of such objects.
- Practical hands-on skills and understanding of simple engineering concepts derived from Mechanics.

Teaching Plan (Theory)

| | |
|---|---|
| **Week 1:** | Newtonian Mechanics (Kinematics & Dynamics) |
| **Week 2:** | Newtonian Mechanics (Kinematics & Dynamics) |
| **Week 3:** | Classical Mechanics at work -deconstructing mechanical systems |
| **Week 4:** | Universal Gravitation |
| **Week 5:** | Oscillations |

| | |
|---|---|
| **Week 6:** | Inertial & Non-inertial frames |
| **Week 7:** | Central force motion |
| **Week 8:** | Understanding rotational dynamics |
| **Week 9:** | Efficiency and mechanical advantage in simple and complex machines: |
| **Week 10:** | Levers, Pulley, Wheel & Axles |
| **Week 11:** | Gear systems |
| **Week 12:** | Hydraulic systems |
| **Week 13 and 14:** | Forms of energy and conversion between different forms of energy |

**References:**


1. *Classical Mechanics.* Herbert Goldstein, Pearson Education, 2011.
2. *A Textbook of Machine Design.* R. S. Khurmi, and J. K. Gupta, S. Chand Publishing, 2005.


**GE 1.2. Engineering Chemistry I [Theory] [Semester I] [2 – 0 – 2]**
**(To be offered by Chemistry faculty members)**

**Course Objective:** This course is designed in such way, so that it provides a flavor of interesting, innovative, programmable and multifunctional materials of chemistry. Students will be exposed to a lot of applications of materials from various walks of our day to day life. Different forms of materials (Biomolecules, drugs, nanomaterials, environment friendly materials etc.) will be discussed at length. Innovative applications of these extremely important materials for drug development, electronic material development, biosensing (like glucose monitoring / disease detection) and environmental remediation etc. will be elaborated, so that students become more aware of the useful materials, which may further be designed, developed and utilized by society as a whole.

**Keywords:** Programmable DNA based materials, Nanomaterials (Nanorods, Nanorobots Nanoclusters etc.), Green Chemistry, Designing of Drugs and their development

**Unit-I**

**Programmable and Multifunctional Materials:**

Basic features and properties of Biomolecules (Carbohydrates, Proteins, Nucleic Acids and Fats) along with their applications in our day to day life as food, medicine, drugs, enzymes for catalysis etc.; Programmable and Multifunctional DNA-Based Materials for various Applications; Chemical and Biological sensors

**Unit-II.**

**Nanochemistry and Nanoscience in our day to day life:**

Synthesis of Nanoparticles (Green and Chemical Methods; Bottom up and Bottom down approach), Various kinds of nanomaterials and nanostructures (Nanoparticles, Nanoclusters, Nanorods, Quantum dots, Nanotubes, Nanorobots etc.) and their applications in various fields like biomedical, electronics, and environment etc.

**Unit-III.**

**Designing of Drugs and their development:**

Discovery and designing of drugs (from concept to marketing); Green Chemistry, it's principles and applications in day to day life, Twelve Principles of Green Chemistry; Use of green chemistry in drug development in Pharmaceutical industry, Organic therapeutic agents used in various diseases, their management and economics in market

**Course Learning Outcomes:**

This course has an aim of making students aware of the structure and properties of engineering materials, polymers and composites, which are most commonly used around us for various applications daily. Also, an elaborative discussion will be done, on one of the most important constituents of life i.e. water, it's properties, types, analysis etc., so that aspects related to water impurities and its different types of treatment methods become clear to them and they can further contribute towards the cause of providing this basic amenity to our society, as and when they get a chance, either by indulging themselves in research with academia or industry. At the end, students will be exposed to various characterization instrumentation techniques, through which they should be able to get a better understanding about various kinds of materials (biomolecules, drugs, nanomaterials etc.)

**Keywords:** Glass, Ceramics, Magnetic materials, Polymers, Engineering materials, Water, Water analysis, Water impurities, Water treatment, Material Characterization, Spectroscopy

**Teaching Plan (Theory)**

| | |
|---|---|
| **Week 1 & 2:** | Basic features and properties of Biomolecules (Carbohydrates, Proteins, Nucleic Acids and Fats) along with their applications in our day to day life as food, medicine, drugs, enzymes for catalysis etc. |
| **Week 3 & 4:** | Programmable and Multifunctional DNA-Based Materials for various Applications |
| **Week 5 & 6:** | Chemical and Biological sensors, Discussion on various examples of such sensors which are being utilized around us. |
| **Week 7 & 8:** | Synthesis of Nanoparticles (Green and Chemical Method: Bottom up and Bottom down approach) |
| **Week 9 & 10:** | Various kinds of nanomaterials and nanostructures (Nanoparticles, Nanoclusters, Nanorods, Quantum dots, Nanotubes, Nanorobots etc.) and their applications in various fields like biomedical, electronics, and environment etc. |
| **Week 11 & 12:** | Green Chemistry, it's principles and applications in day to day life, Twelve Principles of Green Chemistry |
| **Week 13 & 14:** | Discovery and designing of drugs (from concept to marketing); Use of green chemistry in drug development in Pharmaceutical industry, Organic therapeutic agents used in various diseases, their management and economics in market |

**Practicals:**

1. Three-dimensional modeling of DNA structure using various open access softwares available in public domain; Molecular Dynamics simulation of DNA (very simple and rudimentary coarse grained (CG) models, where DNA can be simulated as rods and proteins as ovoids/ spheres)
2. Understanding of principle, designing, fabrication and application of a nano-biosensor (Examples like glucose biosensors or diagnostic kits for COVID-19 etc. can be studied at length).
3. Simulation of a single nano-particle for understanding it's physical and chemical properties in solution
4. Practical assignments on computer-aided drug design/ In-silico drug designing using databases (like Pubchem, zinc database, drug bank etc.), ligand designing softwares, 2D and 3D structure making open access softwares like chem-draw, chimera, pymol etc. and ligand-target interaction (using various molecular docking softwares).
5.

**References:**


1. DNA Beyond Genes: From Data Storage and Computing to Nanobots, Nanomedicine, and Nanoelectronics by Vadim V. Demidov
2. **Templated DNA Nanotechnology Functional DNA Nanoarchitectonics, 2019, by Govindraju, T.**
3. DNA: The Secret of Life by James Watson
4. Structural DNA Nanotechnology by Nedrian Seeman
5. Nanotechnology: Importance and Applications, January 2019, by M.H. Fulekar
6. Scalable Green Chemistry: Case Studies from the Pharmaceutical Industry, by Stefan Koenig

A.C. - 22.11.2022
Annexure - 4.01.41

CLUSTER INNOVATION CENTRE (CIC)

*Category* I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

**DISCIPLINE SPECIFIC CORE COURSE -4 (DSC-4): Engineering through Linear Algebra**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Engineering through Linear Algebra DSC-4 | 4 | 3 | 0 | 1 | Class XII pass | Mathematics till XII |

**Learning Objectives**

Almost, every area of modern science contains models where equations may be approximated by linear equations and linear algebra plays a vital role for finding their solution and interpreting them. This paper aims to enable the student to learn linear models for various physical problems such as traffic flow, electric-circuit flow etc. and to facilitate their solution using concepts of linear dependence, independence, rank, basis, eigenvalues, eigenvectors etc. This paper intends to provide geometrical interpretation of vectors, basis and vector operations in 2 & 3 dimensions and lays the groundwork for a more abstract, pure-mathematical treatment of vector spaces. Also, the importance and application of eigenvalues, eigenvectors in computer graphics, face recognition and many other fields is taught. Students will also learn how to use MATLAB for some simple matrix operations, for finding eigenvalues & eigenvectors, rank etc.

**Learning outcomes**

After completing this course, student should be able to;

- Understand graphical representation of vector and their operations in 2 and 3 dimensions
- Solve linear matrix system AX=B
- Understand the concept of Eigen values and Eigen vectors and their applications in computer graphics, face recognition algorithms & many other fields
- Conceptualize vector spaces, subspaces and their basis functions
- Understand inner product spaces, orthogonal sets, projection and orthogonal diagonalisation
- Learn basic arithmetic operations of matrices in MATLAB
- Implement basic loops (for, while, if else etc) of programming in MATLAB
- Write their own programs for solving system of linear equations

**SYLLABUS OF DSC-4**

**Unit I: (3 weeks)**
**Matrix Algebra**
Algebra of matrices – Review of Determinants - Hermitian, Skew-Hermitian and Unitary matrices - Vectors and vector operations in 2 and 3 dimensions - Solution and application of linear matrix system AX = B

**Unit II: (3 weeks)**
**Eigenvalues and Eigenvectors**
Eigenvalues and eigenvectors, minimal polynomial, Cayley-Hamilton theorem and diagonalization
**Unit III: (4 weeks)**
**Abstract vector spaces, subspaces**
Finite dimensional vector spaces - Linear independence and dependence of vectors, bases, dimension of vector spaces - Finite dimensional inner product spaces

**Unit IV: (4 weeks)**
**Orthogonality**
Orthogonal sets and projections, Gram Schmidt process, orthogonal diagonalisation

**Practical component –**
**Engineering Kitchen Activity (matrix based numerical mathematics software) [Laboratory]**

- Basic arithmetic operations, hierarchy of arithmetic operations
- Declaration and assignment of variables
- Introduction to elementary mathematical functions
- Dealing with matrices and arrays
- Basic programming with loops (for, while, switch), if else statements
- Programs for solving system of linear equations, Orthogonalization
- Creating 2D, 3D plots
- Innovation project

**Essential/recommended readings**

1. *Linear Algebra and its Applications*, D. C. Lay, Addison Wesley, 2005.
2. *A Modern Introduction*, David Poole, *Linear Algebra,* Brooks Cole, 2011.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

## DISCIPLINE SPECIFIC CORE COURSE – 5 (DSC-5): Data Structure and Design

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Data Structure and Design, DSC-5 | 4 | 3 | 1 | 0 | Class XII pass | DSC-3 |

**Learning Objectives**

This course objective is to give an understanding of the real world data representation, organisation and structuring to the student while writing the programs and software. The course makes them familiar with the several types of data structures and their strengths and weaknesses, particularly in a real-world situation.

**Learning outcomes**

- Introduction to Data structure and their significance.
- Practical and theoretical understanding of Dynamic optimization
- Basics of Memory Hierarchy and implementation
- Understanding and implementation of Hashing, Networks and Graphs
- Understanding basics and practical aspects of Searching algorithms in the real world through implementation.
- Introduction and implementation of Heaps and Priority Queues and their comparison with other data structure

**SYLLABUS OF DSC-5**

**Unit I: (4 weeks)**
**Program and data analysis**
Introduction to Data structure, Basic concepts of Correctness, Efficiency and Application, Dynamic optimization Concept, Search Algorithms

**Unit II: (4 weeks)**
**Data items arrangements and processing**
Sorting Algorithms, Introduction to Linear Data Structures: Linked List, Stack and Queues

**Unit III: (3 Weeks)**
**Hierarchical arrangements and processing**
Introduction to Hierarchical Data structure: Tree, Introduction to Heap, Priority Queues and Hashing

**Unit IV: (3 weeks)**

**Network arrangements and analysis**
Networks arrangements, Complex systems and real-world studies, Computational analysis

**Practical component:**
**Engineering Kitchen Activity [Laboratory]:**

- Implementation of Linked list in C/C++
- Implementation of Trees in C/C++
- Implementation of variant of Trees in C/C++
- Implementation of Heaps in C/C++
- Implementation of Hashing in C/C++
- Implementation of Priority Queues in C/C++
- Implementation of Graph and Network based approaches in C/C++
- Innovation Project

**Essential/recommended readings**

1. *Algorithms and Data Structures*, N. Wirth, Prentice-Hall of India, 2009
2. *Data Structures and Algorithms in C++*, A. Drozdek, Course Technology, 2013

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

## DISCIPLINE SPECIFIC CORE COURSE– 6 (DSC-6): Object Oriented Programming

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Object Oriented Programming, DSC-6 | 4 | 3 | 0 | 1 | Class XII pass | DSC-3 |

**Learning Objectives**
The objective is to implement real-world entities like inheritance, hiding, polymorphism etc. in programming. To learn how to bind together the data and the functions that operate on them so that no other part of the code can access this data except that function.

**Learning outcomes**
Upon Completion of this course the students will be able to:

- Recognise features of object-oriented design such as encapsulation, polymorphism, inheritance, and composition of systems based on object identity.

- Use NetBeans, Eclipse, BlueJ as an Integrated Development Environment. Test a program and, if necessary, find mistakes in the program and correct them.
- Take a problem and develop the structures to represent objects and the algorithms to perform operations.
- Name and apply some object-oriented design patterns and give examples of their use.
- Apply standards and principles to write truly readable code.
- Design a class that serves as a program module or package.
- Design applications with an event-driven graphical user interface using java applets.
- Design different android applications such as web apps for the real-world problems.

**SYLLABUS OF DSC-6**

**Unit I: (4 weeks)**
**Introduction to Java**
Introduction to byte code, security and portability, Data Types, variables, operators, arrays, type conversion and casting, type promotion, Control statements, standard input-output, Designing Classes, constructors, methods. access specifiers - public, private, protected

**Unit II: (4 weeks)**
**Classes and Objects**
Introduction, Class revisited, constant objects and constructor, static data members with constructors and destructors, constructor overloading, nested classes, objects as arguments, returning objects, constant parameters and member functions, static data and member functions

**Unit III: (3 weeks)**
**Inheritance, packages and interfaces and Exception Handling**
Math, String, polymorphism - function overloading, function overriding, abstract classes, Dynamic objects - Introduction, array of objects, Exception types, nested try-catch, throw, throws and finally statements

**Unit IV: (3 weeks)**
**Multi Thread Programming**
Thread creation, synchronization and priorities

**Practical component –**
**Engineering Kitchen Activities [Laboratory]**

- Programs implying the use of Arrays, Linked Lists, Strings, Loops
- Programs on Object & Classes from Realistic Environment and Systems
- Programs demonstrating Constructors, Destructors, Methods & other concepts
- Programs Showcasing Inheritance, Polymorphism, Encapsulation & other OOPS features
- Programs on Exception Handling, Packages and Threading
- Reverse Engineering a Java Source/ project/Mobile Application and understanding the concepts
- Mapping the programs with Real life Systems and showcasing the implementation
- Innovation project

**Essential/recommended readings**

1. *Java: The Complete Reference*, 10th Edition. Herbert Schildt. McGraw-Hill, 2017.
2. *C++: The Complete Reference*, 4th Edition. Herbert Schildt. McGraw-Hill, 2012.
3. *Object Oriented Programming with C++*, 6th Edition. E Balagurusamy. Tata McGraw-Hill, 2001.
4. *C++ For Artists: The Art, Philosophy, and Science Of Object-Oriented Programming*. Rick Miller, Pulp Free Press, 2008
5. *Java For Artists: The Art, Philosophy, and Science Of Object-Oriented Programming*. Rick Miller , Pulp Free Press, 2008

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

# B.Tech. (Information Technology and Mathematical Innovations)

## DISCIPLINE SPECIFIC CORE COURSE -7 (DSC-7): Modeling continuous changes through ordinary differential equations

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | |
| **DSE-7 Modeling continuous changes through ordinary differential equations** | **4** | **3** | **0** | **1** | **Class XII pass** | **Mathematics till XII** |

### Learning Objectives

Differential equations have the remarkable ability to translate the real-world problems in mathematical language. This course enables students to study many engineering systems, population dynamics in ecology and biology, mechanics of particles in physics, planetary models etc. involving differential equations. The main objective of the paper is to first analyze and understand the real-world problem through a mathematical lens and then develop the corresponding mathematical model with differential equations in the most realistic sense. Once governing equations are obtained, students should be able to solve them analytically and analyze the solution in physical situations. Students will use MATHEMATICA software for the purpose of simulation.

### Learning outcomes

After completing this course, student should be able to:

- explain the fundamental concepts of ordinary differential equations (ODEs).
- use MATHEMATICA software to solve problems and applications of ordinary differential equations (ODEs) and complex analysis.
- formulate real life problems as ODEs.
- use concepts of ordinary differential equations to solve physical models such as mass spring, pendulum, alternating current circuits, etc.

- Use knowledge of ODEs, the general and particular structure of solutions and different methods for solutions.

## SYLLABUS

**Unit I:** Review of first order differential equations - Variable separable, homogeneous, linear, exact differential equation - Integrating factors - Existence and uniqueness of solution **[12 hours]**

**Unit II:** General solutions of second order differential equation - Homogeneous and non-homogeneous differential equations with constant coefficients - Method of variation of parameters - Method of undetermined coefficients, higher order differential equations with constant coefficients **[12 hours]**

**Unit III:** Planar autonomous linear systems with graphical representation - Determination of stability and classification of equilibrium of a planar nonlinear system by linearization **[9 hours]**

**Unit IV:** Power series solution about a regular point of an analytic ordinary differential equation - Power series solution of Legendre and Bessel's equation - Laplace transform and its application to differential equations **[12 hours]**

**Practical component – The following explorations would be carried out on matrix based numerical mathematics software [30 hours]**

- Plotting of slope fields and solution curves of first order and higher order differential equations
- Graphical analysis of solution of Population model, Pollution Model, Acceleration – Velocity Models
- Projectile motion, Mechanical Vibrations – Motion of Simple Pendulum, Free undamped and damped motion, Forced undamped and damped motion
- Plotting of phase plane diagrams for predator – prey model, competing species, epidemic model and their analysis
- Innovation project

**Essential/recommended readings**

1. *Elementary differential equations*, W. E. Boyce and R. DiPrima, John Wiley, 2005.
2. *Differential equations and boundary value problems: Computing and modeling*, C.H. Edwards and D.E. Penny, Pearson education (Singapore), Pte. Ltd., 2005.
3. *Advanced engineering mathematics*, E. Kreyszig, John Wiley, 1999.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

# DISCIPLINE SPECIFIC CORE COURSE -8 (DSC-8): Operating Systems

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **DSC-8 Operating Systems** | **4** | **3** | **0** | **1** | **Class XII pass** | **DSC-3** |

### Learning Objectives

The objective is to introduce students with basic concepts of Operating System, its functions and services and to familiarize the students with various views and management policies adopted by O.S. as pertaining with processes, Deadlock, memory, File and I/O operations. To brief the students about the functionality of various OS like Unix, Linux and Windows XP as pertaining to resource management and to provide the knowledge of basic concepts towards process synchronization and related issues.

### Learning outcomes

After completing this course, student should be able to;

- Analyze the structure of OS and basic architectural components involved in OS design.
- Analyze and design the applications to run in parallel either using process or thread models of different OS.
- Analyze the various device and resource management techniques for timesharing and distributed systems.
- Understand the Mutual exclusion, Deadlock detection and agreement protocols of Distributed operating system.
- Conceptualize the components involved in designing a contemporary OS.

## SYLLABUS

**Unit I:** Overview: Operating systems – structure, operations, components, types, services, user interfaces. System calls, system programs, system boot**.** **[12 hours]**

**Unit II:** Process management - Processes: concept, scheduling, operations on processes, inter-process communications. Threads – single - and multi-threaded processes. CPU scheduling – criteria, algorithms, multiple-processor scheduling. **[12 hours]**

**Unit III:** Process synchronization – critical-section problem, semaphores, classic synchronization problems, monitors. Deadlocks – characterization, deadlock prevention, deadlock avoidance, deadlock detection, recovery from deadlock. **[12 hours]**

**Unit IV:** Memory management: Main memory – memory allocation schemes. **[9 hours]**

**Practical component:** **[30 hours]**

**Engineering Kitchen Activity [Laboratory]:**

- Write a program for implementation of Priority scheduling algorithms.
- Write a program for implementation of Round Robin scheduling algorithms.
- Write a program for implementation of FCFS scheduling algorithms.
- Write a program for implementation of SJF scheduling algorithms.
- Write a program to implement the producer – consumer problem using semaphores.
- Write a program to implement IPC using shared memory.
- Write a program to implement banker's algorithm for deadlock avoidance.
- Write a program to implement Threading and Synchronization Applications.
- Write a simple Unix commands.
- Innovation Projects

**Essential/recommended readings**

1. Operating System Concepts, 10th Edition, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, John Wiley & Sons, 2009.
2. Manish Kumar Singh, Sachin Kumar, Saibal Kumar Pal, Operating Systems: Concept Building & Problem Solving Approach, Cengage Publication, 2022.
3. John. Lions' Commentary on UNIX® 6th Edition with Source Code. John Lion, San Jose, CA: Peer-to-Peer Communications, 1996.
4. Exokernel: An Operating System Architecture for Application-Level Resource Management., Engler, Dawson R., M. Frans Kaashoek, and James O'Toole Jr., ACM Press, 1995.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

# DISCIPLINE SPECIFIC CORE COURSE -9 (DSC-9): Computer Systems Architecture

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **DSC-9 Computer Systems Architecture** | **4** | **3** | **0** | **1** | **Class XII pass** | **Mathematics till XII** |

## Learning Objectives

The objective is to introduce students with the basic concepts of Computer and the principles underlying systems organization, issues in computer system design, and contrasting implementations of modern systems and to familiarize the students with a fundamental knowledge of computer hardware and computer systems, with an emphasis on system design and performance.

## Learning outcomes

After completing this course, student should be able to;

- have understanding of Computing Systems, Models & Logic, Organization & Architecture of Memory
- have understanding of CPU, I/O Devices
- have understanding of Distributed Computing, Parallel Architecture, Mobile Systems Architecture
- have understanding about Deconstructing Digital Architecture of a computing devices and study of components (Hardware/Software)
- have hands-on experience with Arduino/ARM Interface, Programming & interfacing with Sensors and Parallel Programming using OPENMP, OpenMPI & CUDA.

## SYLLABUS

**Unit I:** Computer arithmetic: fixed point and floating-point representation and arithmetic, numbers conversion. Digitals circuits: Boolean algebra, logic gates, logical synthesis by minimization of Boolean functions **[12 hours]**

**Unit II:** Combinational circuits, sequential circuits (synchronous and asynchronous). Construction of the computer: Von Neumann Architecture **[12 hours]**

**Unit III:** Organization and architecture of memory systems, input/output systems **[12 hours]**

**Unit IV:** Construction of the simple processor. **[9 hours]**

**Practical component:** **[30 hours]**

**Engineering Kitchen Activity [Laboratory]:**

• Logic Gate Designs
• Deconstructing Digital Architecture of a computing devices and study of components (Hardware/Software)
• Hands on experiments with Arduino/ARM Interface
• Programming in Assembler: memory addressing, interrupts, operations on numbers bits and tables, conditional instructions, loops, input/output

**Essential/recommended readings**

1. Computer System Architecture, Morris Mano, Pearson Education, 2008
2. Computer Systems Architecture: a Networking Approach, Rob Williams, Pearson Education, 2006
3. Advanced Computer Architecture: Parallelism, Scalability, Programmability, K. Hwang, McGraw Hill, 2017.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

# COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

**NOTE: The core papers offered in the B.Tech. Course at CIC are Mathematics and Information Technology. Therefore, the students will choose GE offered by Physics, Chemistry, Management and Computational Biology faculty members of CIC.**

## GENERIC ELECTIVES (GE-3.1): Economic Behaviour

### Credit distribution, Eligibility and Pre-requisites of the Course

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| GE 3.1: Economic Behaviour | 4 | 3 | 1 | 0 | Class XII pass | NIL | Management Faculty of CIC |

### Learning Objectives

The purpose of this course is to familiarize the student with the present day modern economics that is both intuitive and relevant to the students. The course introduces the generally accepted concepts of economics both at the micro and macro level. In addition to this, the purpose of this course is to analyse how individual decision-makers, both consumers and producers and the government policies, behave in a variety of economic environments.

### Learning outcomes

After completing this course, student should be able to:

- Understand of the basic structure of the economic ecosystem.
- Conception, of how individuals and firms allocate resources and how market prices are determined.
- Able to understand shifts in supply and demand and their implications for price and quantity sold.
- Understand of how to analyse firms' decisions mathematically using a production function and calculate their optimal level of production, costs, and profits.

- Learn to model the decisions made by firm in a monopoly and an oligopoly, and the implications of these alternate structures for consumer welfare.
- Learn to perceive the nation's economy as a whole and compare the views of Keynes and the classical economists.
- Learn various techniques measuring and tracking macroeconomics using GDP and CPI.
- Analyse the model of full employment and use it to examine important macroeconomic issues, such as the extent to which taxes may depress economic activity and lower the level of GDP.

## SYLLABUS

**Unit I**: The Economic Problem: Scarcity and Choice; Market economies and the price system; Variables, correlation and causation; Recommending appropriate policies **[9 hours]**

**Unit II:** The supply and demand model; Elasticity of supply and demand; Market equilibrium; Demand curve and behaviour of consumers; Supply curve and behaviour of firms **[12 hours]**

**Unit III:** Efficiency of markets; Rise and fall of industries; Monopoly; Antitrust policy; Taxes, transfers and income distributions **[12 hours]**

**Unit IV:** Unemployment, inflation and interest rates; Macroeconomic theory and policies; Measuring theoretical and actual GDP **[12 hours]**

**Essential/recommended readings**


1. Principles of Economics, J.B. Taylor and A. Weerapana, Flatworld, 9th Edition, 2021.
2. Principles of Economics, K. E. Case, R. C. Fair and S. C. Oster, Pearson Education, 13th Edition, 2019.
3. Principles of Economics, N. G. Mankiw, Cengage, 9th Edition, 2021.


**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

**GENERIC ELECTIVES (GE-3.2): Electronic Circuit elements and innovation lab**

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **GE 3.2: Electronic Circuit Elements and Innovation Lab** | **4** | **2** | **0** | **2** | **Class XII pass** | **Mathematics till XII** | **Physics/ Electronics Faculty of CIC** |

### Learning Objectives

This module involves interactive learning of A.C. fundamentals. It helps to understand the basic network analysis of electronic circuits. It also provides the interface to understand the working of various electronic devices and its characteristics. Working of electronic instruments will also be understood.

### Learning outcomes

- After completing this course, student should be able to;
- Concepts of AC fundamentals
- Good knowledge of Network Analysis
- Basics of Diodes and Transistor based devices
- Knowledge of instruments like CRO, Function Generator, Multimeter, etc.

### SYLLABUS

**Unit I:** AC Fundamentals - Concept of voltage and current sources - KVL and KCL - Node voltage analysis and method of mesh currents - Network theorems **[8 hours]**

**Unit II:** PN Junction: variants and applications - Bipolar Junction Transistor (BJT) biasing and amplifier design - Field Effect Transistor (FET) variants – FET biasing and amplifier design **[6 hours]**

**Unit III:** Structure and working of SCR. Structure and operation of LDR, Photo voltaic cell, Photo diode, Photo transitors & LED **[8 hours]**

**Unit IV:** Operational Amplifiers basics and practical circuits - Feedback and oscillator circuits - Voltmeters-Multimeters-Function generator- Cathode ray oscilloscope - Cathode Ray Tube **[8 hours]**

**Practical component –** **[60 hours]**

- Engineering Kitchen Activity (matrix based numerical mathematics software) [Laboratory]
- Characteristics of PN junction and Zener diode filters
- Half wave rectifier.
- Full wave rectifier with 2 diodes.
- LC and Pi filters
- Full wave rectifier with 4 diodes (Bridge rectifier). Input, Output and Transfer characteristics of CE and CC Amplifier.
- Amplifiers and Oscillator characteristics.
- Characteristics of LDR, Photo-diode and Phototransistor.
- Transfer characteristics of JFET.
- Transfer characteristics of MOSFET (with depletion and enhancement mode)
- Characteristics of LED with three different wavelengths.
- Series voltage Regulator.
- Shunt voltage Regulator.
- Characteristics of Thermistor.

**Essential/recommended readings**

1. Circuits and Networks - A.Sudhakar & Shyammohan S. Palli ,TMH, 2010
2. Principles of Electronics- V.K. Mehta and Rohit Mehta, S Chand &Co,2009
3. Electronic Devices and Circuit Theory-R.L.Boylestad and L.Nashelsky, Pearson Education, 2009.

**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

## GENERIC ELECTIVES (GE-3.3): Flow of information in Living Systems

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **GE 3.3 Flow of Information in Living Systems** | **4** | **2** | **0** | **2** | **Class XII pass** | **NIL** | **Chemistry / Biology Faculty of CIC** |

Learning Objectives

This module is designed to:

- Introduce students to nuclear events such as replication, transcription, translation, condensation, repair and recombination etc.
- Introduce gene regulation in prokaryotes and eukaryotes
- Introduce various biophysical and biochemical techniques related to these nuclear events

Learning Outcomes

Upon completion of the course the students will be able to:

- Understand the structure and function of DNA and RNA
- Build concept about the processes of the Central Dogma of the living systems (replication, transcription, translation, recombination etc.)
- Develop an understanding of prokaryotic and eukaryotic gene regulation

### SYLLABUS

**Unit I:** Structure of the nucleic acids **[8 hours]**

Structure and biophysical properties of the DNA and RNA, forms of DNA and RNA, DNA binding domains, the evolution of DNA

**Unit II:** Replication, Transcription and Translation **[8 hours]**

DNA replication models, Enzymes of DNA replication, DNA replication in prokaryotes and eukaryotes, regulation of DNA replication;

RNA polymerases, Transcription in prokaryotes, Eukaryotic transcription, Regulation of transcription in Prokaryotes and Eukaryotes, Eukaryotic chromatin

Ribosomes, translation in prokaryotes, translation in eukaryotes

**Unit III:** DNA repair and recombination **[8 hours]**

Energetics and accuracy of information transfer, DNA damage and repair, Molecular recombination

**Unit IV:** DNA packaging and chromatin structure, regulation of gene expression in eukaryotes **[6 hours]**

**Practical Component** **[60 hours]**

- Agarose gel electrophoresis of DNA/ Proteins
- SDS-PAGE Electrophoresis
- Polymerase Chain Reaction (PCR)
- Primer design
- Spectrometry
- Modelling of DNA and RNA forms and motifs through computational tools

**Essential/recommended readings**


1 Biology, Raven et al. Tata Mc Graw –Hill, 2013

2. Biology: Global Approach. Reece et al., Pearson Educations, Global edition, 2014


**Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

## GENERIC ELECTIVES (GE-3.4): Explorations in Living Systems

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| ***GE 3.4 Explorations in Living Systems** | 4 | 2 | 0 | 2 | Class XII pass | NIL | Chemistry / Biology Faculty of CIC |

***GE 3.4 can be opted by students in either 3rd or 4th semester.**

### Learning Objectives

This module is designed to:

- Introduce students to the living system in terms of their hierarchal organization and their distinction from the nonliving.
- The specific objective of the module is to introduce biology even to students with no biology background and enable them to understand living systems.
- To enthuse students with tools and techniques for studying biology.
- Introduce students to the origin and evolution of living systems
- Introduce students to the essence of model organisms for studying biology

### Learning outcomes

After studying this course, the students will be able to:

- Understand the diversity and complexity of living systems
- To comprehend different fields within Bio-Sciences
- To understand experimental processes undertaken in Biology
- Will develop a philosophical understanding of the origin and evolution of living systems, the nature of genetic materials etc.

## SYLLABUS

**Unit I: Introduction and organization of living systems [6 hours]**

Introduction to living state: (living versus non-living), Hierarchy of organization of living systems and classification (cellular, multicellular and organismic and population levels), Cell as the unit of life.

**Unit II: Origin and diversification of the living systems [8 hours]**

Nature of the genetic material (DNA versus RNA), Introduction to molecular evolution, Origin of life, Evidence of evolution, Theories of evolution, Creating living systems (synthetic cell).

**Unit III: Designing living systems [8 hours]**

Nature of biological processes - Approaches to study Biology: Observational and Experimental, Physiology and Behaviour

**Unit IV: Tools and materials for studying living systems [8 hours]**

Observational, synthetic and reductionist approaches for studying living organisms, Microscopy, Centrifugation and separation techniques as basic tools for studying components of living systems, Model organisms.

**Practical components [60 hours]**

**Basic equipment and techniques**

a. Observation or permanent slides of pollens, microbes, hydra, Daphnia and bacteria under a microscope

b. Separation techniques:

- Fraction of cell organelles through centrifugation
- Separation of chlorophyll pigments by paper chromatography

**Exploring different levels of organization (using model organisms)**

a. Tissue organization and diversity in cell shapes: studying through plant and animal tissues sections

b. Inflorescence as a model of organization

c. Understanding parts of the flower

**Studying cells:**

a. Bacterial growth curve analysis

b. Genomic DNA isolation

c. Preparation of metaphase chromosome

d. Preparation of karyotypes using photographs of metaphase spreads

e. Demonstration of osmosis and plasmolysis

**Essential/recommended readings**


1. *Biology*, Raven et al., Tata McGraw-Hill, 2013.
2. *Biology: Global Approach*. Reece et al., Pearson Educations, Global edition, 2014.

**Appendix-59**
**Resolution No. 14-1 (14-1-8)**

## INDEX
## Cluster Innovation Centre
## B.Tech. (Information Technology and Mathematical Innovations)


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| 2. | Pool of Generic Electives (GEs)<br>1. Strategies and Concept for Innovation Management<br>2. Electronics at Work & Circuit Simulations<br>3. *In silico* Biology<br>4. The Living world: Systems Approach | **3-24** |
| 3. | Pool of Discipline Specific Electives (DSEs)<br>1. Mathematical Modeling & Simulation<br>2. Computational Fluid Dynamics (CFD)<br>3. Technology based solutions of societal issues<br>4. Medical Imaging techniques<br>5. Virtual Reality | |


## Semester-V


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| 3. | Pool of Discipline Specific Electives (DSEs)<br>1. Health Data Analysis<br>2. Game Development Using UNITY<br>3. 3D Printing using Blender<br>4. Applications of Data Science: A case study approach<br>5. Urban Computing<br>6. IT Project Leadership<br>7. Fabrication of nanomaterials for devices<br>8. IoT, Security and Machine Learning<br>9. Integral Transforms and Applications | |

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| 1. | Discipline Specific Cores (DSCs)<br><br>1. Numerical Methods for Computational Mathematics<br>2. Information Security<br>3. Artificial Intelligence | **49-73** |
| 2. | Pool of Generic Electives (GEs)<br><br>1. e-Business: Organisation and Strategy<br>2. Control Systems<br>3. Genomics and Proteomics | |
| 3. | Pool of Discipline Specific Electives (DSEs)<br><br>1. Mathematical Modeling & Simulation<br>2. Computational Fluid Dynamics (CFD)<br>3. Technology based solutions of societal issues<br>4. Medical Imaging Techniques<br>5. Computational Analysis of OMICS data<br>6. Virtual Reality<br>7. Complex Systems<br>8. Research and Methodology | |

**B.Tech. (Information Technology and Mathematical Innovations)**

**SEMESTER-IV**

## Course Structure

## B. Tech. (Information Technology and Mathematical Innovations); Semester-IV

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | |
|---|---|---|---|---|---|
| | | L | T | P | Total |
| IV.1 DSC 10 | Applied probability and statistics | 3 | 0 | 1 | 4 |
| IV.2 DSC 11 | Analysis and Design of Algorithms | 3 | 0 | 1 | 4 |
| IV.3 DSC 12 | Data Base Management Systems | 3 | 0 | 1 | 4 |
| IV.4* GE 4 | IV.4.1 Strategies and Concept for Innovation Management | 3 | 1 | 0 | 4 |
| | IV.4.2 Electronics at Work & Circuit Simulations | 2 | 0 | 2 | |
| | IV.4.3 *In silico* Biology | | | | |
| | IV.4.4 The Living world: Systems Approach | | | | |
| IV.4* DSE 2 | IV.4.5. Mathematical Modeling & Simulation[#] | 0 | 0 | 4 | 4 |
| | IV.4.6. Computational Fluid Dynamics (CFD) [#] | | | | |
| | IV.4.7. Technology based solutions of societal issues[#] | | | | |
| | IV.4.8. Medical Imaging techniques[#] | | | | |
| | IV.4.9. Virtual Reality[#] | | | | |
| IV.5 AEC 4 | Choose one from a pool of AEC | - | - | - | 2 |
| IV.6 VAC 4 | To be added from the pool VAC | - | - | - | 2 |
| IV.7** SEC 4 | Choose one from a pool of SEC | - | - | - | 2 |
| IV.7** IAPC 2 | Problems drawn from Industry, Society and Villages | 0 | 0 | 2 | 2 |
| Grand Total | | | | | 22 |

***Any one from IV.4. (Either GE 4 or DSE 2) may be opted by students**
****Any one option from IV.7 (Either SEC 4 or IAPC 2) may be opted by students**
**[#]These DSE 2 papers will be available in Semester VI also.**

- **Key: L: Lecture, T: Tutorial, P: Project/Practical/Internship**

## DISCIPLINE SPECIFIC CORE COURSE -10 (DSC-10)
## IV.1. Applied Probability and Statistics

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | |
| **Applied probability and statistics, DSC 10, IV.1.** | **4** | **3** | **0** | **1** | **12th pass** | **Mathematics till XII** |

### Learning Objectives

Probability theory is the branch of mathematics that deals with modelling uncertainty. It is an important course as it has direct application in areas such as genetics, finance and telecommunications. It also forms the fundamental basis for many other areas in the mathematical sciences, such as modern optimization methods and risk modelling. This course introduces probability theory, random variables. This unit will concentrate on the following: Sampling distributions, hypothesis testing, interval estimation, likelihood, analysis of categorical data, joint, marginal and conditional distributions, and regression. R software will be introduced through practical classes in the beginning of the course. Its use will be supported with examples in lectures and tutorials with supplementary material on the course website.

### Learning outcomes

- A good understanding of basic concepts of statistical distributions.
- A good understanding of elementary probability theory, the laws of probability and the use of Bayes and various other theorems of probability.
- Able to derive the probability density functions of transformations of random variables and use these to generate data from various distributions.
- Able to represent and statistically analyze data both graphically and numerically.
- A good understanding of exploratory data analysis by working on datasets related to human resources, image segmentation analysis, pollution levels in a city, health diagnosis, etc. along with the ability to write a short-report describing a simple statistical data set.
- Able to translate real-world problems into probability models.

## SYLLABUS

**Unit I:** Probability space - Conditional probability - Bayes theorem – Independence - Descriptive measures (Mean, median, mode, standard deviation, dispersion, moments) - Random variables - Joint distributions **[9 hours]**

**Unit II:** Discrete distributions (Bernoulli, Binomial, Poisson) and their properties (Expectation, variance, conditional expectation, moments) - Continuous distributions (Uniform, Normal, Exponential) with their properties (Expectation, variance, conditional expectation, moments) **[12 hours]**

**Unit III:** Joint, marginal and conditional distributions - Weak and strong law of large numbers, -Central limit theorem - Curve fitting - linear regression, Correlation **[9 hours]**

**Unit IV:** Sampling distributions - Hypothesis testing, interval estimation - Likelihood, analysis of categorical data - Test statistic and their significance **[15 hours]**

**Practicals– [30 Hours]**

**Computer program R and its application to simple models**

- Introduction to basic syntax of R for arithmetic operations, creating arrays and matrices
- Getting data into R and basic data analysis in R
- Statistical computations in R (evaluation of density functions and distribution functions, computation of descriptive measures for given data)
- Data visualization in R
- Innovation Project

**Essential/recommended readings**

1. Introduction to Probability and Statistics for Engineers and Scientists, S.M.Ross, AcademicPress,2009.

2. Applied Statistics and Probability for Engineers, D.C. Montgomery and G.C. Runger, John Wiley and Sons, 2014.

3. Design of Experiments: A No-Name Approach, Thomas Lorenzen and Virgil Anderson, CRC Press 1993.

4. Statistics and Experimental Design in Engineering and the Physical Sciences, Vol. I and II, N.L. Johnson and F.C. Xeen Leone, Wiley Interscience, 1977.

## DISCIPLINE SPECIFIC CORE COURSE -11 (DSC-11)
## IV.2. Analysis and Design of Algorithms

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Analysis and Design of Algorithms, DSC 11, IV.2.** | **4** | **3** | **0** | **1** | **Class XII pass** | **Programming Fundamentals** |

### Learning Objectives

The objective is to teach techniques for effective problem-solving in computing. The use of different paradigms of problem-solving will be used to illustrate clever and efficient ways to solve a given problem. In each case, emphasis will be placed on rigorously proving the correctness of the algorithm. In addition, the analysis of the algorithm will be used to show the efficiency of the algorithm over the naive techniques.

### Learning outcomes

After completing this course, student should be able to;

- Understand basics of algorithmic analysis and their practical understanding of the real-world examples.
- Learn mathematical design of algorithms and their algorithmic correctness through proofs.
- Understand computational complexity with asymptotic notations and their analysis.
- Have an introduction of different types of paradigm and domain of algorithms such as NP completeness.
- Have hands-on experiments on dynamic programming and greedy approaches.
- Do hands-on experiments on advanced data structures such as AVL tree, Red black, Search heuristics, Approximation algorithms, Distributed and parallel algorithms.

### SYLLABUS

**Unit I:** Algorithmic analysis and modeling - Algorithmic proofs - Computational complexity - Asymptotic notation and analysis **[12 hours]**

**Unit II:** Sorting methods analysis – Randomization – NP Completeness – Advanced data structure **[12 hours]**

**Unit III:** Geometric algorithms – Graph algorithms – Linear Programming – Design paradigm such as Divide & conquer **[10 hours]**

**Unit IV:** Dynamic Programming – Greedy Approaches – Search heuristics – Approximation algorithms – Compression and streaming algorithms – Distributed and parallel algorithms. **[11 hours]**

**Practicals - [30 Hours]**

**Write program to perform**

- operation count for a given pseudo code
- Bubble sort for any given list of numbers.
- Insertion sort for any given list of numbers.
- Quick Sort for the given list of integer values.
- Merge Sort on the given two lists of integer values.
- Binary Search for a given set of integer values recursively and non-recursively.

**Write program to find**

- Maximum and Minimum of the given set of integer values.
- a solution for the knapsack problem using greedy methods.
- the minimum cost spanning tree using Prim's Algorithm.
- the minimum cost spanning tree using Kruskal's Algorithm.
- a solution for job sequencing with deadlines problem.

**Write program**

- for all pairs shortest path problems.
- to solve the N-QUEENS problem.
- to solve the Sum of subsets problem for a given set of distinct numbers.

**Essential/recommended readings**


- Introduction to Algorithms. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. MIT Press, 2009.
- Problem Solving with Algorithms and Data Structures Using Python. Bradley W. Miller, and David L. Ranum. Franklin, Beedle & Associates, 2011.
- Data Structures and Algorithms in C++, A. Drozdek, Course Technology, 2013.
- The Art of Computer Programming, Vol. 1,2,3,4. Donald E. Knuth, Pearson Education, 2013.

## DISCIPLINE SPECIFIC CORE COURSE -12 (DSC-12)
## IV.3. Database Management Systems

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Database Management Systems, DSC 12, IV.3.** | **4** | **3** | **0** | **1** | **12th pass** | **NIL** |

### Learning Objectives

The objective is to present an introduction to database management systems, with an emphasis on how to organize, maintain and retrieve - efficiently, and effectively - information from a DBMS. In addition, Course also introduces the present day modern databases with implementation on real-world projects.

### Learning outcomes

After completing this course, student should be able to;

- Install, configure, and interact with a relational database management system.
- Describe, define and apply the major components of the relational database model to database design.
- Learn and apply the Structured Query Language (SQL) for database definition and manipulation.
- Utilize a database modeling technique for a single entity class, a one-to-one (1:1) relationship between entity classes, a one-to-many (1:M) relationship between entity classes, a many-to-many (M:M) relationship between entity classes, and recursive relationships.
- Define, develop and process single entity, 1:1, 1:M, and M:M database tables.
- Learn and implement the principles and concepts of information integrity, security and confidentiality.
- Apply ethical computing concepts and practices to database design and implementation.

## SYLLABUS

**Unit I:** Traditional Files & Databases – Database Management Systems **[9 hours]**

**Unit II:** Relational Model - ER Modeling – Constraints, Query language & features – Normalization – Indexing **[12 hours]**

**Unit III:** Transaction Processing & Concurrency Control – PL/SQL Basics Graph Databases - Data Modeling Techniques & UML **[12 hours]**

**Unit IV:** Analysis of Data using Mining Techniques – MongDB - NoSQL – Object Oriented Databases - Study of Real-World Applications **[12 hours]**

**Practicals-** **[30 Hours]**

- ER Diagram of Existing systems and new systems
- SQL Commands, Structures & execution of Commands on Test Database
- Creation of Databases and identifying the Constraints
- Execution of DDL, DML, TCL Queries on created database
- XML Databases • Executing Aggregate Functions and Extraction of Data elements
- Programs on Database Objects including Procedures, Functions, Exception
- Modeling of Systems and Requirements using UML
- Design of Application(s) using Mining Techniques
- Reverse Engineering & Study of a Database System Architecture
- Innovation Project

**Essential/recommended readings**


- Fundamental of Database Systems, R. Elmasri and S. B. Navathe, Pearson Education Asia, 7th edition, 2016.
- Database System Concepts, Abraham, H. and Sudershan, S., 5 Ed., McGraw-Hill, 2013
- Introduction to Data Mining, Pang, N. T., Pearson Education, 2013
- Database System: The Complete Book, Jeffrey Ullman, Jennifer Widom, and Héctor García-Molina, Pearson Education, 2008
- Data Modeling: A Beginners Guide, Andy Oppel, McGrew Hill, 2010

# COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

**NOTE: The core papers offered in the B.Tech. Course at CIC are Mathematics and Information Technology. Therefore, the students will choose GE offered by Physics, Chemistry, Management and Computational Biology faculty members of CIC.**

## Credit distribution, Eligibility and Pre-requisites of the Course

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **Strategies and Concept for Innovation Management GE 4, IV.4.1.** | **4** | **3** | **1** | **0** | **12th pass** | **NIL** | **Management Faculty of CIC** |

## Learning Objectives

The course presents an integrated view of the skills, tools and techniques in innovation management. Innovation relies on different disciplines that ranges from creativity to organizational behaviour. Rather than focusing on just one aspect of innovation management – Idea generation, the course delves into other aspects such as consumer behaviour, teamwork, leadership and thought processes that would foster creativity and a better understanding of managing innovation.

## Learning outcomes

After completing this course, student should be able to:

- Understand the basic need to innovate for growth, profit and survival
- Comprehend that the ability to innovate and innovation management as vital core competency.
- Identify innovation opportunities
- Distinguish between incremental, standard and radical innovations
- Optimize a portfolio of high risk and low risk innovation
- Understand how the in box thinking lead to out of the box creativity

## SYLLABUS

**Unit-I. The innovation imperative:** Why innovate?; Innovation to energize; Innovate for growth and profit; innovate for survival; Discussion of relevant case study. **[11 hours]**

**Unit-II. The innovation portfolio:** What to innovate?; Vision, portfolios and feelings; Identifying the right question, feelings and needs; Innovating Experiences, Battling Commoditization; Technology and Psychology; Creating Emotional Appeal; Searching for Innovation Opportunities; Innovation Portfolios for Established Organizations **[10 hours]**

**Unit-III. The innovation voices:** How to innovate?; Thinking 'Inside and outside The Box'; Profiling Product for Profit and Growth; Understanding the voice of the product, customer and organization; Fostering creativity in organizations**.** **[12 hours]**

**Unit-IV. The innovative mind:** Who Innovates?; Three Levels of Innovation; The Individual Innovator; Creativity Muscles; Innovative Teams; Building a Global Team; The Innovative Organization **[12 hours]**

**Essential/recommended readings**

- Innovation Management: Strategies, concept and tools for growth and profit, S. Maital D.V.R. Sheshadri, Response Books, 2007.
- Innovation Management and New Product Development, P. Trott, Pearson Education, 7th Edition, 2021.
- Innovation and Entrepreneurship, M. Kennard, Routledge, 2021.

## GENERIC ELECTIVES (GE4, IV4.2): Electronics at work & circuit simulation

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | | |
| **Electronics at work and Circuit simulation, GE 4, IV.4.2.** | **4** | **2** | **0** | **2** | **Class XII pass** | **Basic knowledge of science** | **Physics/ Electronics Faculty of CIC** |

### Learning Objectives

This is a basic introductory module to provide an insight of the field of electronics to the students. In this paper students learn about basics of analog and digital electronics. The emphasis is on basic electronics components and devices and their application in real world.

### Learning Outcomes

After the completion of the course, the students will be familarized with

- concepts of Electronics.
- following analog electronic components and their identification: resistor, capacitor, inductor, power source, transducer, sensor, detector, switch, Potentiometer - Integrated Circuit – Transformer;
- following digital electronic components, circuits, devices and their identification: logic families, logic gates, Boolean algebra - Combinational circuits: adders, encoders, decoders, multiplexer and de- multiplexer - Sequential circuits: like flip flops, counters, shift registers, memories
- following semiconductor devices, circuits and their identification: PN Junctions characteristics, Zener and Avalanche breakdown, diode applications, transistor & applications. Operational Amplifier (Op Amp): inverting and noninverting amplifier, integrator, differentiator, summing amplifier.
- practical and circuit simulations to understand basic electronics circuits used in everyday life.

## SYLLABUS

**Unit I: Analog World**: resistor, capacitor, inductor, power source, transducer, sensor, detector, switch – Potentiometer - Integrated Circuit – Transformer. **[10 hours]**

**Unit II: Digital World**: logic families, logic gates, boolean algebra - Combinational circuits: adders, encoders, decoders, multiplexer and de-multiplexer - Sequential circuits: like flip flops, counters, shift registers, memories. **[10 hours]**

**Unit III: Semiconductor Devices**: PN Junctions characteristics, Zener and Avalanche breakdown, diode applications, transistor & applications. Operational Amplifier (Op Amp): inverting and non-inverting amplifier, integrator, differentiator, summing amplifier.
**[10 hours]**

**Practicals -** **[60 Hours]**

- Design basic electric switch board used in home
- Simulation of rectifier circuit
- Designing device charging circuit
- Deconstructing mobile charger circuit
- Simulation of CE amplifier circuit
- Designing basic amplifier circuit using transistors
- Simulation of phase shift oscillator circuit
- Designing of oscillator circuit for frequencies in audio range
- Simulation of digital clock circuit
- Innovation Project: Deconstructing mobile phone circuit

## Recommended/ Suggested Readings:


- Electronic Principles. Albert Paul Malvino, McGraw-Hill, 1998
- Electronic Devices & Circuit Theory. Robert L. Boylestad, and Louis Nashelsky, Pearson Education, 2009
- Digital Logic and Computer Design. M. Morris Mano, Pearson Education, 2008
- Signals and Systems. Alan V. Oppenheim, Alan S. willsky, and Nawab S. Hamid, Prentice Hall, 1997
- Art of Electronics. Paul Horowitz, and Winfield Hill, Cambridge University Press, 2008
- Practical Electronics for Inventors, Fourth Edition – by Paul Scherz and Simon Monk, Mc Graw Hill Education, 2022

## GENERIC ELECTIVES (GE 4, IV.4.3): *In Silico* Biology

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | | |
| ***In Silico* Biology, GE 4, IV.4.3.** | **4** | **2** | **0** | **2** | **Class XII pass** | **NIL** | **Chemistry/ Biology Faculty of CIC** |

**Learning Objectives**

This module is designed to:

- Develop an understanding of the advancement of computational models and simulations in studies applied to complex biological phenomena.
- Aware students of different types of bioinformatics analysis software and their related applications so that they can solve biological problems

**Learning Outcomes**

**Upon completion of the course the students will be able to:**

- Do computational simulations using protein and DNA sequences
- Be able to build computational models of biological data and systems
- Will be aware of the software and databases related to computational biology
- Will do homology modelling, docking, building cladograms etc.

### SYLLABUS

**Unit I: Handling protein and DNA sequences [12 hours]**

Sequence patterns and profiles; Sequence file formats; Basic concept and definition of sequence patterns, motifs and profiles; sequence representations types; Sequence similarity based search engines (BLAST and FASTA); Pattern based and Motif-based searches; Profile-based database searches; Basic concepts of sequence similarity, identity and homology; homologues, orthologues, paralogues and xenologues sequences; Scoring matrices; Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles; Basic concepts of sequence alignment, pair wise alignment; application of sequences alignments.

Multiple sequence alignments; concept of dendrogram and its interpretation, phylogeny and cladistics.

**Unit II: Handling biological data and data models [10 Hours]**

Types of Biological data- Genomic DNA, cDNA, transcriptomics and RNA sequence analysis; Primary Databases: Nucleotide and protein sequence databases, Metagenomic and Environmental Sequences, Literature Databases, Secondary or Derived Databases; Sequence motifs Databases; Composite Databases; Genome organization databases; Organism specific database; Database search engines.

**Unit III: Programming languages and software [08 hours]**

Algorithm and programming languages, Stochastic models; Introduction to biopython; Introduction to new software and bio packages

**Practicals - [60 hours]**

- Sequence analysis (BLAST, FASTA).
- Database (NCBI, DDBJ, EMBL).
- Motif and Promoter searches (e.g. CD-Search, SMART, SignalP)
    - Phylogenetic analysis (PHYLIP, MEGA)
    - Protein interaction (STRING, BioGRID)
    - Protein structure, Function (PROSITE programs, Chimera
    - Gene expression, function (GEA, Gene card, OMIM)
    - Introduction to molecular docking

**Essential/Suggested Readings**


- Bioinformatics: Sequence and genome analysis, David mount, Cold Spring Harbor Laboratory Press; 2nd edition, 2013.
- Introduction to Bioinformatics, Arthur M. Lesk, OUP Oxford, 4th edition, 2014.
- Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley-Blackwell, 3rd Edition, 2015.

## GENERIC ELECTIVES (GE 4, IV.4.4): The Living world: Systems Approach

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| The Living world: Systems Approach *GE 4, IV.4.4 | 4 | 2 | 0 | 2 | Class XII pass | NIL | Chemistry/ Biology Faculty of CIC |

***This paper can be opted by students in either 3rd or 4th semester.**

### Learning Objectives

This module is designed to:

- Introduce students to the living system in terms of their hierarchal organization and their distinction from the nonliving.
- The specific objective of the module is to introduce biology even to students with no biology background and enable them to understand living systems.
- To enthuse students with tools and techniques for studying biology.
- Introduce students to the origin and evolution of living systems
- Introduce students to the essence of model organisms for studying biology

### Learning outcomes

After studying this course, the students will be able to:

- Understand the diversity and complexity of living systems
- To comprehend different fields within Bio-Sciences
- To understand experimental processes undertaken in Biology
- Will develop a philosophical understanding of the origin and evolution of living systems, the nature of genetic materials etc.

### SYLLABUS

**Unit I: Introduction and organization of living systems [6 hours]**

Introduction to living state: (living versus non-living), Hierarchy of organization of living systems and classification (cellular, multicellular and organismic and population levels), Cell as the unit of life.

**Unit II: Origin and diversification of the living systems [6 hours]**

Nature of the genetic material (DNA versus RNA), Introduction to molecular evolution, Origin of life, Evidence of evolution, Theories of evolution, Creating living systems (synthetic cell).

**Unit III: Designing living systems [6 hours]**

Nature of biological processes - Approaches to study Biology: Observational and Experimental, Physiology and Behaviour

**Unit IV: Tools and materials for studying living systems [12 hours]**

Observational, synthetic and reductionist approaches for studying living organisms, Microscopy, Centrifugation and separation techniques as basic tools for studying components of living systems, Model organisms.

**Practicals - [60 hours]**

**Basic equipment and techniques**

a. Observation or permanent slides of pollens, microbes, hydra, Daphnia and bacteria under a microscope
b. Separation techniques:
    - Fraction of cell organelles through centrifugation
    - Separation of chlorophyll pigments by paper chromatography

**Exploring different levels of organization (using model organisms)**

a. Tissue organization and diversity in cell shapes: studying through plant and animal tissues sections
b. Inflorescence as a model of organization
c. Understanding parts of the flower

**Studying cells:**

a. Bacterial growth curve analysis
b. Genomic DNA isolation
c. Preparation of metaphase chromosome
d. Preparation of karyotypes using photographs of metaphase spreads
e. Demonstration of osmosis and plasmolysis

**Essential/recommended readings**


- Biology, Raven et al., Tata McGraw-Hill, 2016.
- Biology: Global Approach. Reece et al., Pearson Educations, Global edition, 2020.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
## IV.4.5. Mathematical modelling & Simulation

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Mathematical modeling & simulation# DSE-2, IV.4.5** | **4** | **0** | **0** | **4** | **12th pass with Maths** | **Linear Algebra, Differential Equations** |

**# This course will also be available to the students in semester VI**

### Learning Objectives

This interactive learning module intends to provide capabilities and basic understanding of system modelling and simulation performance. It will emphasis on analysis of dynamical behavior of physical, electrical, mechanical, social, biological, chemical, and financial systems along with applications in engineering and other applied sciences. The simulation will be done with the MATLAB software platform.

### Learning outcomes

- After completing this course, student should be able to;
- Understand the mathematical and computational tools for modelling and simulation of various systems.
- Apply basic concepts of fractional calculus.
- Identify, model analyze, and simulate various systems using simulation tools.
- Know how the simulation help to analyze system graphically.
- Describe the behavior of different physical and virtual systems.

### Syllabus

**Practicals –** **(120 Hours)**

- Modeling of integer and non-integer systems
- Introduction to basic simulation tools
- Simulation performance of integer and non-integer systems
- Chaotic behavior of integer and non-integer systems
- Parameter optimization to improve the efficiency of the system
- Model validation and performance analysis with data
- Innovation Project

### Essential/recommended readings


- Theory of modeling and simulation, Zeigler B.P., Praehofer. H., Kim I. G., 2nd Edition. Academic press, 2000.
- Theory of Fractional Dynamic Systems, Lakshmikantham, V., Leela, S., Vasundhara Devi,
  J. Cambridge Academic Publishers, Cambridge, 2009.
- Fractional-order nonlinear systems: modeling, analysis and simulation, Petras, I., SpringerVerlag Berlin Heidelberg, Germany, 2011.
- Chaos: An Introduction to Dynamical Systems, K.T. Alligood, Sauer, Tim D., Yorke James
  Springer, 1996.
- Nonlinear Dynamics and Chaos, Strogatz, S. Reading, MA: Addison-Wesley, 1994.
- Optimization and Dynamical Systems, Helmke U., Moore J. B, SpringerVerlag, 1993.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
## IV.4.6. Computational Fluid Dynamics (CFD)

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Computational Fluid Dynamics# (CFD), DSE-2, IV.4.6** | **4** | **0** | **0** | **4** | **12th Pass With Maths** | **Calculus, Linear Algebra & Differential Equations** |

**#This course will also be available to the students in semester VI**

### Learning Objectives

This interactive practical paper aims to enable the students to visualize different types of problems of flow and heat transfer in various fields. Blood flow within arteries, biological tissues, heat transfer within biological tissues, flow within circular pipes, flow within an aquifer are some of the important application of CFD. In this paper, students will visualize CFD models, mathematical analysis of these visualizations, simulate them numerically using mathematical softwares such as ANSYS, COMSOL and post process the obtained numerical results.

## Learning Outcome

After completing this paper, students will be able;

- Visualise and implement mathematical models of flow and heat transfer problems in different applications.
- Implement existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design of UDF based problem specific modules in ANSYS/COMSOL
- Validate their numerical results with experimental data (if available) for suggesting new designs.

## Syllabus

**Practicals - (120 Hours)**

- Governing equations for CFD: The continuity, momentum and energy equations with their physical interpretation
- Interpretation of different set of flow conditions such as inflow, outflow, no slip boundary etc as per problem requirement.
- CFD mesh generations, structured and unstructured mesh, mesh refinement (local & global), adaptive mesh.
- Implementation of existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design and modification of existing modules using UDF (User defined functions) in ANSYS/COMSOL as per the problem requirement.
- Post-processing of numerically simulated results

## Essential/ Recommended Readings:


- Computational Fluid Dynamics: A practical Approach (2019) by Jiyuan Tu, Guan Yeoh, Chaoqun Liu, 2nd Edition, Publisher: Butterworth-Heinemann.
- Computational Fluid and Particle Dynamics in the Human Respiratory system (2012) by Jiyuan Tu, Kiao Inthavong, Goodarz Ahmadi, Biological and Medical Physics, Bio-medical Engineering, Publisher: Springer.
- Multiphysics Modelling using COMSOL: A First Principle Approach (2011), by Roger W. Pryor, Jones and Bartlett Publishers, London, Singapore.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
## IV.4.7. Technology based solutions of societal issues

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Technology based solutions of societal issues#, DSE-2, IV.4.7** | **4** | **0** | **0** | **4** | **12th pass** | **Programming Fundamentals, Basic knowledge of biology.** |

**#This course will also be available to the students in semester VI**

### Learning Objectives

This course is designed for students to give them hands-on experience of working on interdisciplinary research problems, which may have direct impact or relevance for the linkage of society and technology. This will broaden their horizon regarding the identification of an issue and then step by step way of solving the same, either theoretically or experimentally by acquiring the required technology-based skill-sets.

### Learning outcomes

After completing this course, student should be able to;

- Identify a research problem related to a societal issue, which may be solved using technology
- Acquire the required technical skill-sets, which will be needed for solving such problems
- Get the hands-on training for working on real societal issues requiring technology-based interventions, so that students can become more sensitive and responsible for solving such issues

### Syllabus

**Practicals –** **(120 hours)**

- Developing an understanding related to societal issues specifically in the sectors of water, food, electricity, textiles, housing, energy, defense and human health etc., which may require a technology-based intervention
- Identification of a problem as per interest of the student, and solving it using innovative and interdisciplinary approaches

- Working on problems based on artificial intelligence-based biosensors, Electrochemical biosensors, wearable biosensors etc. for various applications related to society
- Building machine learning models on various datasets specially related to health issues for the identification, diagnosis or prediction of the disease
- Computational modeling/ simulation of nanoparticles and their usage in drug delivery applications for various diseases. Examples can be like neuro-simulation of drug-loaded nanoparticles for understanding the pathway for diseases like mental depressive disorders.

### Essential/recommended readings

- Sensing and Artificial Intelligence Solutions for Food Manufacturing; Editors: Charles Oluwaseun Adetunji, Daniel Hefft, CRC Press
- Mathematical Modeling of Biosensors by Romas Baronas, Felikas Ivanauskas, Juozas Kulys, (2021); Springer International publishing
- Biosensors and Nanotechnology: Applications in Health Care Diagnostics (2017), Editor: Zeynep Altintas; Wiley Publishers
- Research papers/ Reviews from peer reviewed reputed journals, related to the identified problem/ issue

## DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
## IV.4.8. Medical Imaging Techniques

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Medical Imaging Techniques#, DSE-2, IV.4.8** | **4** | **0** | **0** | **4** | **12th Pass** | **Basic knowledge of python** |

**#This course will also be available to the students in semester VI**

### Learning Objectives

This practical paper is designed to provide hands on experience to build data driven module for computer vision, with applications in medical image analysis. This practical paper enables the students to build deep learning architecture, such as filters, activation functions, loss functions;

regularization techniques such as e.g. batch normalization and dropout. Student can implement different non-linear optimization algorithms that are used when training the medical imaging networks on different imaging tools.

## Learning outcomes

- Training and validation of image dataset, classification and regression, supervised and unsupervised learning, bias and variance, loss function, generalization error, accuracy, precision, to medical image dataset.
- Can implement deep learning parameters, such as e.g. depth, learning rate, hyper parameter, overtraining and regularization in softwares.
- Implementation of different deep learning architecture for classification and segmentation of diagnosis of various diseases.
- Can simulate hybrid deep learning architecture and models used in medical imaging.

## Syllabus

**Practicals - (120 Hours)**

- Implementation of basic Medical imaging tools.
- Feature extraction, segmentation, systematic evaluation and validation on medical image datasets using data driven architectures.
- Designing different machine learning and deep learning based models for segmentation and classification of medical imaging datasets.
- Performance analysis of different deep learning architecture in terms of statistical parameters.
- Case studies on some recent advances in analysis of retinal, CT, MRI, ultrasound and histology images.

## Essential/recommended readings


1. The Handbook of Medical Image Perception and Techniques, by Ehsan Samei and Elizabeth A. Krupinski, second edition, Publisher Cambridge University Press.
2. Medical Imaging by DS Guru, K.C. Santosh, Nilanjan Dey, Sameer Antani, Publisher CRC Press.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -2 (DSE-2)
## IV.4.9. Virtual Reality

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Virtual Reality#, DSE 2, IV.4.9** | **4** | **0** | **0** | **4** | **Class XII pass with Maths** | **C++** |

**#This course will also be available to the students in semester VI**

### Learning Objectives

The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications

### Learning outcomes

At the end of the course, the students will be able to:

- Understand geometric modelling and Virtual environment.
- Be able to do 2D and 3D geometrical modelling
- Develop Virtual Reality applications.

### Practicals - **(120 Hours)**

The course will be conducted completely on a hands-on mode and project-based learning. The basic concepts will be explained and each concept will be augmented by small tasks in UNITY. Animations and physical simulations will be introduced to the students through an appropriate Virtual environment. Following tasks will be covered in the lab:

- Introduction to the Virtual environment
- Introducing frame of reference and modelling transformations
- Animation in virtual environment – projectile motion, flight/ car simulation, Ferris wheel, pendulums, etc.
- Visualising Human Anatomy/ geographical regions/ environment/ monuments in the VR environment
- Modelling a store/ classroom/ office/ mall in VR

**Essential/recommended/ suggested readings**


- Virtual Reality Systems, John Vince, Pearson Education India, 2002. https://all3dp.com/2/blender-3d-printing-tutorial/
- Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, Morgan Kaufmann, 2018
- Virtual Reality, Samuel Greengard, MIT Press, 2019.
- Virtual and Augmented Reality, Paul Mealy, Wiley, 2018.

# Semester-V

**B.Tech. (Information Technology and Mathematical Innovations)**

**SEMESTER-V**

# B. Tech. (Information Technology and Mathematical Innovations),

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | |
|---|---|---|---|---|---|
| | | L | T | P | Total |
| V.1 DSC 13 | Linear Programming and Game Theory | 3 | 0 | 1 | 4 |
| V.2 DSC 14 | Data Communication and Networking | | | | |
| V.3 DSC 15 | Software Engineering | | | | |
| V.4* GE 5 | V. 4.1 Consumer behaviour and Marketing Research | 2 | 0 | 2 | 4 |
| | V.4.2 Circuit Analysis and Synthesis | | | | |
| | V.4.3 Genes to Genomes | | | | |
| V.5** DSE 3 | V.5.1. Health Data Analysis# | 0 | 0 | 4 | 4 |
| | V.5.2 Game Development Using UNITY# | | | | |
| | V.5.3. 3D Printing using Blender# | | | | |
| | V.5.4 Applications of Data Science: A case study approach | | | | |
| | V. 5.5 Urban Computing | | | | |
| | V.5.6. IT Project Leadership# | | | | |
| | V.5.7. Fabrication of nanomaterials for devices# | 1 | 0 | 3 | 4 |
| | V.5.8 IoT, Security and Machine Learning | 1 | 0 | 3 | 4 |
| | V.5.9 Integral Transforms and Applications | 1 | 0 | 3 | 4 |
| V.6*** SEC 5 | Any one from the pool of SEC | - | - | - | 2 |
| V.6*** IAPC | Academic Internship | 0 | 0 | 2 | 2 |
| Grand Total | | | | | **22** |

***Any one GE paper with opted by students from GE 5 papers**

****Any one DSE paper will be opted by students from DSE 3 papers**

*****Student will either opt for SEC 5 or choose internship (IAPC) in paper V.**

**# These papers are also being offered in 3rd Semester**

**Key: L: Lecture, T: Tutorial, P: Project/Practical/Internship**

# DISCIPLINE SPECIFIC CORE COURSE – 13 (DSC-13)
# V.1. Linear Programming and Game Theory

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| ***Linear Programming and Game Theory,*** **DSC 13, V.1** | **4** | **3** | **0** | **1** | **12th Pass** | **NIL** |

## Learning Objectives

To provide an understanding of the optimization of linear models in the many areas. This course starts with the definition of LPP, underlying assumptions and modeling of problems. Illustration of graphical methods will help to conceive the idea behind the solution of LPP. This will also help the reader to visualize the overall concept though explained for only two decision variables. Once the concept becomes clear, the theoretical as well as logical approach of the most popularly used simplex method will be explained.

## Learning outcomes

After completing this course, student should be able to

- Formulate linear programming models for given real situations
- Learn simplex method and its computational efficiency
- Formulate dual problems and understand economical interpretation of primal dual relationship
- Analyze post optimality and its economical interpretation
- Solve Transportation problems and assignment problems
- Learn some basic concepts of game theory
- Learn linear programming solution of games with mixed strategies

## Syllabus

Unit I: Formulation of Linear Programming Models - Theory of simplex method - optimality and unboundedness - the simplex algorithm - simplex method in tableau format - Computational efficiency of the technique **(10 hours)**

Unit II: Introduction to artificial variables – two-phase method, Big-M method and their comparison - Formulation of the dual problem, Primal-dual relationships, Economic interpretation of the dual **(10 Hours)**

Unit III: Introduction to Post optimality analysis - Dual Simplex Method and its application - Formulation of the Transportation problem - Algorithm for solving transportation problem - Northwest

- corner method, least cost method and Vogel approximation method for determining the starting basic solution **(10 hours)**

Unit IV: Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem - Formulation of two person zero sum games - Solving two person zero sum games - Games with mixed strategies - Graphical solution procedure -Linear programming solution of games **(15 hours)**

**Practicals -** **(30 Hours)**

Program with Solver and its application to simple models

- Formulation of the model in Solver
- Solution of LPP with Solver
- Sensitivity analysis with Solver
- Solution of Transportation and Assignment problem with Solver
- Innovation Project

**Essential/recommended readings**


- Linear Programming and Network Flows, Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, (2nd edition), John Wiley and Sons, India, 2004.
- Introduction to Operations Research, F. S. Hillier and G. J. Lieberman, (9th Edition), Tata McGrawHill, Singapore, 2009.
- Operations Research, An Introduction, Hamdy A. Taha, (8th edition), Prentice-Hall India, 2006.


## DISCIPLINE SPECIFIC CORE COURSE – 14 (DSC-14)
## V.2. Data Communication and Netwroking

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Data Communication and Networking DSC 14, V.2** | **4** | **3** | **0** | **1** | **12th Pass** | **Programming, Data Structure, Design and Analysis of Algorithms** |

**Learning Objectives**

This course introduces to the students, fundamentals of data communication and computer networks, organization of network architecture, its components and functions. The course gives them a practical understanding of client-server programming and also introduces the basics of network security.

## Learning outcomes

Through this course, students:

- Will understand Data communication, Communication Channels, Topologies and Networking Applications.
- Will have knowledge of Layered Architecture & Models, Network Devices, Error Management, and Network Protocols.
- Will have exposure to Network Architectures of Enterprise Applications.
- Will be able to understand the Routing Mechanism and TCP/UDP applications on Network Devices, Socket Programming, and Web/Server Based Applications.

## Syllabus

**Unit I:** Introduction to Data Communication; Components and Basics-Communication Channels – Topologies **(15 Hours)**

**Unit II**: Networking Applications - Layered Architecture & Models – Network Devices **(10 Hours)**

**Unit III:** Introduction to Data Link - Error Management **(10 Hours)**

**Unit IV:** Network Protocols – Network Security – Network Architectures of Enterprise Applications **(10 Hours)**

**Practical Component- (30 Hours)**

- Simulate Cyclic Redundancy Check (CRC) error detection algorithm for noisy channels.
- Simulate and implement stop and wait protocol for noisy channels.
- Simulate and implement go-back n sliding window protocol.
- Simulate and implement selective repeat sliding window protocol.
- Simulate and implement the Dijkstra algorithm for shortest-path routing.
- Implementation of socket programming.

## Essential/recommended readings


- Data Communication and Networking, Forouzan, B.A., Tata McGraw-Hill. 2013
- Computer Networking: A Top-Down Approach Featuring the Internet, Kurose, .F. *a*nd Ross, K.W., 3rd Ed., Addison Wesley, 2004
- Computer Networks, A S Tanenbaum, PHI, IV Ed, 2003
- Computer Communication Networks, W. Stallings, PHI, 1999

# DISCIPLINE SPECIFIC CORE COURSE – 15 (DSC-15)
# V.3. Software Engineering

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Software Engineering, DSC-15, V.3** | **4** | **3** | **0** | **1** | **12th Pass** | **NIL** |

### Learning Objectives

This course objective is to train students in developing software and large scale software products in a systematic manner through requirement analysis, design principles, quality assurance, software process models, and estimation of schedules, productivity and cost.

### Learning outcomes

After completing this course, student should be able to understand:

- Software Engineering basics, Software Process Models, Software Requirement Process.
- System Design and Testing Approaches.
- Scheduling, Productivity and Cost Estimation.
- Risk Management.

### Syllabus

**Unit I:** Introduction to software Engineering – Software Engineering Principles – Software metrics – Software development life-cycle. **(10 Hours)**

**Unit II:** Software Process Models – Software Requirement Process -– System Design – Testing. **(10 Hours)**

**Unit III:** Scheduling Estimation Models. **(10 Hours)**

**Unit IV:** Productivity Estimation – Cost Estimation – Schedule Estimation – Risk Management – Case Study **(15 Hours)**

### Practicals - **(30 Hours)**

- Analysis of a desktop/enterprise Software Applications under lens of software design fundamentals
- Requirement gathering, verification and specification of a new Software Project

- Creating Prototypes and outlines of problems in the frame of Software engineering aligned with design methodologies
- Reverse engineering management aspects any Open Source Software Project and identify Software
- Software Projects sign off with Project Charter and management of project plans
- Hands on Experiment on Requirement Management, Deliverable attributes of Software projects
- Design a Software Application, Product, and Service and integrate with existing system
- Estimation of Costing of Software, Time sheet management in estimation of Effort, Resource Management
- Design of User Guides, Software Manuals, Update Documentation, Release Guides, Deployment Guides, FAQs
- Basic Understanding on use of Agile & Scrum
- Innovation Project

**Essential/recommended readings**


- Requirements Risks Can Drown Software Projects, Leishman and Cook, Computer (November 2001).
- Software Engineering: A Look Back and A Path to the Future. Leveson, Nancy, December 14, 1996.
- Applied Software Project Management, Andrew Stallman & Jennifer Greene, O`Reilly, 2005.
- R . S. Pressman, "Software Engineering – A practitioner's approach", 5th Ed., McGraw Hill Int. Ed., 2001.
- K. K. Aggarwal &Yogesh Singh, "Software Engineering", 2nd Ed., New Age International, 2005.

# COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

**NOTE: The core papers offered in the B.Tech. Course at CIC are Mathematics and Information Technology. Therefore, the students will choose GE offered by Physics, Chemistry, Management and Computational Biology faculty members of CIC.**

## GENERIC ELECTIVES (GE-5)
## V. 4.1. Consumer Behaviour and Marketing Research

### Credit distribution, Eligibility and Pre-requisites of the Course

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Consumer Behavior and Marketing Research, GE-5, V.4.1 | 4 | 2 | 0 | 2 | 12th Pass | NIL | Management Faculty of CIC |

### Learning Objectives:

The success of business depends on a thorough understanding of how consumers behave and why they behave in a way they do to any business actions such as change in any of the 4 P's of marketing. This course provides the useful insights into consumer psychology with special focus on how consumers think, feel and react to marketing stimuli. Effective marketing research reduces the percentage of product or service failures. It is important for the participants to know the fundamental concepts in the field of marketing research.

### Learning Outcomes

After completing the course, student should be able to:

- Understand factors important for consumer buying behaviour
- Understand various consumer behaviour models
- Understand basis of marketing decisions on consumer insights
- Understanding nature and scope of marketing research
- Different methods of data collection, sampling techniques
- Learning various univariate and multivariate data analysis techniques
- Ethical issues in MR

## SYLLABUS:

**UNIT I: Consumer mind mapping and Consumer behaviour models (6 Hours)**

Manager and Consumer perspectives, Mapping consumer mind, Deterministic and probabilistic approaches, Howard and Sheth model, Nicosia and Engle and Blackwell model.

**Unit II: Consumer knowledge and perception (6Hours)**

Types of thresholds, consumer memory networks, Consumer engagement, Perceived risk, antecedents and consequences of consumer decision making, Learning and motivation theories

**Unit III: Marketing Research & Types of Research Design (8 Hours)**

Nature and Scope of Marketing Research, Marketing Research process, Exploratory, Descriptive and Conclusive Research

**Unit IV: Data collection & Ethical Research (10 Hours)**

Sample design and field work, Data coding, Data analysis, Use of statistical software for hypotheses testing, Ethical considerations.

**Practicals - (60 Hours)**

- Data collection and Coding
- Marketing Research Case studies
- Data analysis of the already existing products based on surveys
- Innovation projects based on data collection and marketing reseach

**Essential/ recommended readings:**


- Assael, H. (2009). *Consumer behaviour and marketing action*. New Delhi: Cengage Learning.
- Blackwell, R. D., Miniard, P. D., & Engle, J. F. (2009). *Consumer behaviour*. USA: Thomson-South Western.
- Evans, M., Jamal, A., &Foxall, G. (2009). *Consumer behaviour* (2nd ed.). New Jersey: John Wiley & Sons.
- Malhotra, N.,& Dash, S. (2015*). Marketing Research: An Applied Orientation* (6th ed.). New Delhi: Pearson.
- Burns, A. C., Veeck, A.F. &Bush, R. F. (2017). *Marketing Research* (8thed.). New Delhi: Pearson.
- Churchill, G., Iacobucci, D., & Israel, D. (2010). *Marketing Research: A South Asian Perspective*. Delhi: Cengage

## GENERIC ELECTIVES (GE-5)
## V. 4.2. Circuit Analysis and Synthesis

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Circuit Analysis and Synthesis, GE 5, V. 4.2 | 4 | 2 | 0 | 2 | 12th Pass | NIL | Physics/ Electronics Faculty of CIC |

### Learning Objectives

This module is designed to enable the students with skills (i) for analyzing an electronic circuit and (ii) to synthesis a circuit based on practical needs. All necessary theoretical inputs are explained in details to achieve the said objective. Module also explains the calculation methods to determine voltages, currents, power factors and other attributes of electrical circuits.

### Learning Outcomes

After completing the course the students will be able to

- understand difference between various types of electric circuits like DC and AC Circuits with Resistors in series and parallel and understanding related basic laws like Ohm's Law, Kirchhoff's laws
- understand various circuit analysis methods like Mesh current and node voltage method of analysis for D.C and A.C. circuits, Network reduction and network theorems for dc and ac circuits, voltage and current division, source transformation, star delta conversion, Thevenins and Norton's Theorem, Superposition Theorem, Maximum power transfer theorem, Reciprocity Theorem
- learn about resonance and coupled L, C, R circuits: Series, parallel resonance and their frequency response, Quality factor and Bandwidth, Tuned circuits, Single tuned circuits- Transient response for DC circuits, Transient response of RL, RC and RLC Circuits
- learn about characterization of two port networks in terms of Z, Y and h parameters.

## Syllabus

**Unit I:** Basic circuits analysis - Ohm's Law - Kirchoffs laws - DC and AC Circuits - Resistors in series and parallel circuits -Mesh current and node voltage method of analysis for D.C and A.C. circuits - Phasor Diagram - Power, Power Factor and Energy **(10 Hours)**

**Unit II:** Network reduction and network theorems for dc circuits - voltage and current division, source transformation - star delta conversion - Thevenins and Nortons Theorem – Superposition Theorem - Maximum power transfer theorem - Reciprocity Theorem - Resonance and coupled circuits – Series, parallel resonance and their frequency response - Quality factor and Bandwidth, Characterization of two port networks in terms of Z,Y and h parameters. **(10 Hours)**

**Unit III:** Tuned circuits - Single tuned circuits, Transient response for DC circuits - Transient response of RL, RC and RLC Circuits **(10 Hours)**

## Practicals - **(60 Hours)**

- Verification of nodal voltage and mesh current methods for solving circuits.
- Verification of important network theorems.
- Study of the response of the first order R-C and R-L circuits.
- Study of the response of a series and a parallel RLC circuits.

**Essential/recommended readings**

- Linear circuits: analysis and synthesis - Ayyagari Ramakalyan, Oxford University Press, 2005,
- Linear circuit analysis - Chi Kong Tse, Addison-Wesley, 1998

## GENERIC ELECTIVES (GE-5)
## V. 4.3. Genes to Genomes

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Genes to Genomes, GE-5, V.4.3. | 4 | 2 | 0 | 2 | 12th Pass | NIL | Chemistry/ Biology Faculty of CIC |

## Learning Objectives

This module is designed to:

- Introduce students to the basics of genetics and genome biology
- Introduce students to genome sequencing analysis.
- Introduce students to population genetics.

## Learning outcomes

After studying this course, the students will be able to:

- Comprehend the basis of the inheritance of characters from simple to complex
- Understand and analyze population-based inheritance patterns
- Generate and analyze Pedigree charts and family trees for inherited diseases

## Syllabus

**Unit I: Discovery of the gene concept and beyond** **(8 Hours)**

Mendelian and non-Mendelian inheritance, Gene interaction, Epistasis, Linkage and recombination

**Unit II: Population genetics** **(7 Hours)**

Hardy Weinberg Principle and equilibrium, deviations and role of evolution in the equilibrium, metabolic and other diseases

**Unit III: Eukaryotic genome complexity** **(7 Hours)**

Junk DNA, Characteristics, Genome mapping techniques, Genome evolution, Transposable elements, Coding and noncoding RNA,

**(8 Hours)**

## Practicals - **(60 Hours)**

- Punnett square, T-test
- Analysis of gene mapping
- Pedigree analysis
- Calculations to understand genome evolution
- Mathematical equations and models for prediction of inheritance

**Essential/recommended readings**


1. *Biology*, Raven et al., Tata McGraw-Hill, 2013.
2. *Biology: Global Approach*. Reece et al., Pearson Educations, Global edition, 2014.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V.5.1 Health Data Analysis

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Health Data Analysis# DSE-3, V.5.1** | **4** | **0** | **0** | **4** | **12th Pass** | **NIL** |

**# This course will also be available to the students in semester III**

### Learning Objectives

This is a practical based module is designed to:

- Introduce students to the complexity of data related to health and diseases.
- Introduce to the students the method of collection of data, their visualization and analysis

### Learning outcomes

After studying this course, the students will be able to:

- Comprehend and handle complex data related to health and diseases, which are usually large.
- Do survey-based research for data collection, their visualization by different methods and their analysis including the statistical analysis

### Syllabus

**Practicals -** **(120 Hours)**

- Art and Science of preparation of questionnaire for collection of health data: types and ethical consideration
- Types of data: Likert scale data and quantitative data related to health and diseases their collection methods
- Understanding how data is organized to facilitate analysis in the healthcare setting.
- Data visualization through histograms and tables
- Data visualization through heat maps
- Integration, understanding and selection of appropriate data visualization techniques to effectively communicate results
- Identifying ways in which data quality can be compromised and applying remedies
- Evaluation of data from varying sources to create meaningful presentations.

- A survey-based research on epidemiology and public health by collecting real data from the field area. It will include study designing, data collection, visualization and analyses of the data
- The results will be used for the preparation of a project report/manuscript.

**Essential/recommended readings**

- Introduction to Data Science in Healthcare Reading: https://www.r2library.com/Resource/detail/1584265329/ch0007s0170
- Analytics and (Precision Medicine) Decision Support Reading: https://www.r2library.com/Resource/detail/0128006811/ch0014s0163
- Hype Cycle for Healthcare Providers, 2019 (Gartner) Reading: Pages 3-7
- https://www.r2library.com/Resource/detail/0340950056/ch0004s0092
- Principal components analysis https://www.r2library.com/resource/detail/0803625642/ch0006s0141 ANOVAhttps://www.r2library.com/Resource/detail/0781781531/ch0015s0490

## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.2. Game Development using UNITY

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Game Development using UNITY#, DSE 3, V. 5.2** | **4** | **0** | **0** | **4** | **Class XII pass with Mathematics** | **$C^{++}$** |

**# This course will also be available to the students in semester III**

**Learning Objectives**

The Learning Objectives of this course are

- to introduce the students to the game engine platform UNITY
- to give a basic on how to develop a game using this game engine.
- to design, develop and finalize a game on either an Android or an IOS platform

**Learning outcomes**

This course gives students an insight into developing a game either on a mobile or a desktop platform. Upon completion of the course the students would be able to-

- Possess basic ability to convert game idea into a working prototype
- Learn basic techniques for animation and simulation

- Extend the concept of game development on Web, console or VR platforms
- Develop a creative and aesthetic mindset by creating a good looking functional UI for the developed game

**Practicals -** **(120 Hours)**

The course will be conducted completely on a hands- on mode. The basic concepts will be explained and each concept will be augmented by small tasks initially on UNITY before designing and developing a game. The following tasks will be performed in lab:

- Introduction to Unity's Interface and Unity's Basics
- Rigid Bodies and Colliders
- Audio Source and UI Elements
- Moving Character with Code
- Introduction to Variables; Operations with Variables; Functions; Conditional Statements; Loops; Coroutines; Classes
- Creating animations, simulations and background
- Designing, developing and finalizing a game

**Essential/recommended readings**


- *Learning C# by Developing Games with Unity 5.x*, G. Lukosek, Packt publishing Ltd, 2016
- *Developing 2D Games with Unity: Independent Game Programming with C#*, Jared Halpern, Apress, 1st Edition, 2018
- *Unity in Action: Multiplatform Game Development in C# with Unity 5*, Joe Hocking, Manning publications, 3rd Edition, 2022
- *Unity From Zero to Proficiency (Foundations)*, Patrick Felicia, LPF publishing, 4th Edition, 2015


## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.3. 3D printing using Blender

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **3D printing using Blender#, DSE 3, V. 5.3** | **4** | **0** | **0** | **4** | **Class XII pass with Mathematics** | **NIL** |

**# This course will also be available to the students in semester III**

## Learning Objectives

The Learning Objectives of this course are

- to introduce the students to Blender
- to understand the basic concepts of 3D modelling and printing using Blender
- to identify the pitfalls in 3D printing
- to apply the slicing techniques and generate G code

## Learning outcomes

This course gives students an insight into using the free and open source ware Blender for 3D printing. Upon the successful completion of the course the students are expected to generate 3D models of some simple objects like flower vase, geometrical figures, tessellation tiles, bottle lids, etc.

## Practicals - **(120 Hours)**

The course will be conducted completely on a hands- on mode. The basic concepts will be explained and each concept will be augmented by small tasks initially on Blender before moving on to 3D printing. The following tasks will be performed in lab:

- Introduction to the User Interface and navigation in blender
- Creating simple geometrical objects like planes, cube, cylinder, cone, spheres, spirals, etc. on blender
- Movement, scaling and rotation transformations
- Simulation, animation and rendering
- Polygonal modelling for 3D printing
- 3D printing of simple geometrical objects
- Moving on to more complex 3D printing

**Essential/recommended/ suggested readings**

1. *Blender 3D printing tutorials for beginners,* https://all3dp.com/2/blender-3d-printing-tutorial/
2. *Blender for 3D printing design* https://www.youtube.com/watch?v=5CyaeBBQIkc&list=PLvCZK2JKGQlNt8uEM5_J12Qj7eO5MqV03
3. *3D printing from zero to hero in Blender* https://www.udemy.com/course/learn-3d-printing/

## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.4. Applications of Data Science: A Case Study Approach

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Application of Data Science: A Case Study Approach, DSE 3, V. 5.4.** | **4** | **0** | **0** | **4** | **Class XII pass with Mathematics** | **Linear Algebra; Probability and Statistics; Basic programming** |

### Learning Objectives

- Introduce the students to Python based toolkits
- Understand the application of mathematics concepts to data science
- Formulate hypothesis for the case study under consideration
- Inculcate problem solving mind-set among students

### Learning outcomes

The students will be enabled to identify a case study (for e.g. weather forecasting, stock market prediction, sentimental analysis, crime prediction, etc) and apply the fundamentals of mathematics and programming languages. The students will also understand the use of various Python tools such as NumPy, Matplotlib, etc.

### Practicals - **(120 Hours)**

The course will be conducted completely on a hands- on mode. The basic concepts will be explained and each concept will be augmented by small exercises on lab either using Python/ MATLAB or R. A case study would be identified to implement all the concepts. Following tasks will be done in the computer lab

- Introduction to programming tools (Python/ MATLAB/ R)
- Visualising Data through Bar Charts, Line Charts, Box Plots, Histogram
- Scrapping web for data (Eg., Various social media sites)
- Cleaning the data
- Using models like K nearest neighbours; Naïve Bayes, Linear and Logistic Regression, Decision Trees, Neural Network, Clustering., Random forest to analyse the data
- Identifying a case study (for e.g. weather forecasting, stock market prediction, sentimental analysis, crime prediction, health data analytics etc.) for a mini project

**Essential/recommended/ suggested readings**

- Data Science from Scratch: First principles with Python, Joel Grus, 2nd Edition, O'Rielly Media Inc, 2019. https://all3dp.com/2/blender-3d-printing-tutorial/
- Python Data Science Handbook: Essential Tools for working with Data, 2nd Edition, O'Rielly Media Inc, 2022
- Practical Statistics for Data Scientist, Peter Bruce, Andrew Bruce and Peter Gedeck, 2nd Edition, O'Rielly Media Inc, 2020
- Python for Data Science, L.M. John Paul Mueller, Wiley, 2019.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.5. Urban Computing

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit-distribution of the course | | | Eligibility criteria | Prerequisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Urban Computing** DSE 3, V.5.5 | 4 | 0 | 0 | 4 | 12th Pass | Programming languages, data Structure, Algorithm design and analysis |

### Learning Objectives:

This course introduces an interdisciplinary filed, is the science of using computing technology in solving urban challenges such as crowds, traffic, and pollution, governance issues etc. Urban computing research also focuses on acquiring an understanding of the nature of urban phenomena, predict the future of cities, and plan their development.

### Learning Outcomes:

- Learn to formulate challenges urban problems.
- Understand ways of data acquisitions, integration, and modeling skills necessary for urban computing research.
- Learn to model cities, develop large-scale statistical models, and use visualization technologies to pose and answer questions.
- Solve issues related to public health, sustainable use of limited energy resources, emergency preparedness, and societal stability etc
- Work in blended project teams with people from a variety of disciplines.
- Understand ways to solve practical hands-on problems faced by urban spaces/cities. activities.

**Practicals -** **(120 Hours)**

The course will be conducted completely on a hands-on mode and project based learning. The basic concepts of Urban Computing will be explained and associated real world challenging problems will be identified.

- Problem solving on Urban context text analytics including Smart mobility and smart environments.
- Acquisition and processing of high resolution remotely sensed data for urban applications;
- Practical work on Location-based service in smart cities
- Experiments on Data acquisition, storage, management, analysis, sharing
- Agent-based simulation for urban dynamics
- Hands on working on Urban sensor network data and applications.
- Students will be exposed to the practical application of Urban Computing concepts and learn how to solve real world urban problems.

### Essential/recommended readings


- Zheng, Y. (2019). Urban computing. MIT Press.
- Yin, H. (2023). An overview of urban data variety and respective value to urban computing. Handbook of Mobility Data Mining, 1-13.
- Haldorai, A., Ramu, A., & Murugan, S. (2019). Computing and Communication Systems in Urban Development: A Detailed Perspective. Springer Nature.
- Zheng, Y., Capra, L., Wolfson, O., & Yang, H. (2014). Urban computing: concepts, methodologies, and applications. ACM Transactions on Intelligent Systems and Technology (TIST), 5(3), 1-55.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.6. IT Project Leadership

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit-distribution of the course | | | Eligibility criteria | Prerequisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| IT Project Leadership#, DSE 3, V.5.6 | 4 | 0 | 0 | 4 | 12th Pass | NIL |

**# This course will also be available to the students in semester III**

## Learning Objectives

The key focus of this project-based course is to develop a deep understanding of facilitators and obstructions while developing and managing IT developments as a product and its life cycle. Innovations in IT have led some businesses to flourish, while others have faltered due to massive changes brought by information technology. IT is hard to manage, therefore understanding its applications, planning and management are ensuring intended changes where innovations are realized and the unintended ones are kept under control. The course covers information system, information management, IT strategy, and IT governance

## Learning outcomes

After completing this course, student should be able to;

- contribute to information system planning and strategy formulation in corporate enterprises and complex administrations.
- have a deeper understanding of a socio-technical approach to the deployment of IT in organisations
- understand frameworks for analysing strategic issues of IS deployment and a familiarity with the most relevant current issues.
- develop insight into cases of the strategic planning of information systems often demand

## Syllabus **(120 Hours)**

### Practicals -

- Understanding IT and software characteristics and applications. processes, methods and tools. Scenario based view of IT manager's role and KRA's.
- Understanding evolving IT landscape and dynamics, IT and networking as applied to enterprises in public and commercial sector.
- Software management, Software life cycle, Process and Project metrics, Software quality management and assurance, software cost estimation, the make or buy decision, Automated estimation tools.
- IT enabled products or services, ITIL service management model, software as a service, software as a platform, IT service strategy, new service designing and development process, common IT setups and Systems.
- Fundamental aspects of daily IT operations, human factors in organization, acquisition and procurement, research and Development, Logical planning. Managing digital networks and security.
- Management Information Systems, Strategic planning in regulated and competitive IT industries, the management and marketing of a technology-based enterprise,
- Evaluating their legal constraints, responsibilities and ethics, Social and ethical aspects of IT, The principles and methods of asset valuation, Interpretation and measurement, financial statements risk assessment, Capital market, Capital budgeting and the effects of economic regulation on capital formation, IT Policy and Regulation

### Essential/recommended readings


- Managing the Internet of Things: Architectures, Theories, and Applications Editors: Jun Huang & Kun Hua, Chongqing University, China & Lawrence Technological University, USA, ISBN9781785610288.
- "Management" by Stoner J A and Freeman R E, ISBN 10: 8131707040 / ISBN 3: 9788131707043
- "Management: Principles and Practice" by S K Mandal ISBN: 9788184952209, 8184952201 Edition: 1stEdition, 2011, Pages: 500.
- "Principles and Practices of Management" by Khusboo Manoj ISBN-10: 9380921128 ISBN-13: 978-9380921129.
- "Principles and Practice of Sport Management" by Carol A Barr, ISBN-13: 9781284034172 Product With Access Code, 606 pages.
- "Better Software Practice for Business Benefit: Principles and Experiences" by Colin Tully and Richard Messnarz, ISBN-10: 0769500498 ISBN-13: 978-0769500492.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V.5.7. Fabrication of nanomaterials for devices

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | |
| **Fabrication of nanomaterials for devices#, DSE-3, V.5.7** | **4** | **1** | **0** | **3** | **Class XII pass** | **Basic knowledge of science** |

**# This course will also be available to the students in semester III**

### Learning Objectives

This course is designed to expose students regarding the fabrication and applications of various types of nanomaterials. Students will be performing hands-on experiments and will get themselves acquainted with the fascinating world of nanotechnology and it's interdisciplinary applications.

## Learning outcome

Through this paper, students would be learning:

- About the basics of nanomaterials and characterization techniques
- To fabricate nanomaterials using chemical or green synthesis
- To characterize nanomaterials using various physicochemical techniques
- To explore the interdisciplinary applications of fabricated nanomaterials in electronic devices, optical devices, computing devices, health devices, drug delivery, environmental remediation and energy etc.

## Syllabus

### Theory **(15 Hours)**

Introduction of Nanoscience and nanomaterials; synthesis (Chemical as well green methods) and characterization techniques (including spectroscopic, X-RD, Zetasizer, electron micrography etc.); Discussion on basic, innovative and recent advancements in the field of nanostructures / Nano-formulations/ Nano-devices / Nano-sensors etc. for targeting various applications related to the interdisciplinary fields

### Practicals - **(105 Hours)**

- Identifying a research problem based on fabrication of devices using nanotechnology
- Identifying the requirement of type of nanomaterials (nanoparticles, quantum dots, nanostructures etc.) depending upon their physical and chemical properties as per the identified research problem
- Chemical or green synthesis of nanomaterials based on the selective, identified protocols, which may later be modified for the novel method of synthesis
- Characterization of nanomaterials using various physicochemical techniques like UV-absorption spectroscopy, FT-IT spectroscopy, X-ray diffraction, Zetasizer, Dynamic light scattering, Scanning electron microscope (SEM), HR-TEM, FESEM etc. for understanding their size, shape, charge, morphology etc.
- Exploring the role of fabricated nanomaterials in electronic devices, optical devices, computing devices, drug delivery, environmental remediation and energy etc.

## Essential/recommended readings


- Nanotechnology For Dummies; By Richard D. Brooker, Earl Boysen (2011), Wiley Publisher
- Nanotechnology: An Introduction; By Jeremy Ramsden (2011), Elsevier Science Publisher
- Research papers and reviews from journals of international repute like Nanotechnology Reviews (NTREV) journal, NANO Reviews, Nature Nanotechnology

## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V. 5.8. IoT, Security and Machine Learning

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit-distribution of the course | | | Eligibility criteria | Prerequisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| IoT, Security and Machine Learning, DSE 3, V.5.8 | 4 | 1 | 0 | 3 | 12th pass with Physics and Mathematic | Programming Fundamentals, Probability and statistics, Computer System Architecture |

### Learning Objectives

This course introduces students to the field of machine learning, deep learning, security with python and its interaction with the Internet of Things (IoT) devices/ sensors. The course will cover topics such as security models, attacks, concept of privacy preservation, threats to machine learning models, and IoT devices. Students will be implementing various privacy preserving machine learning techniques with Python/ C or in MATLAB. The students will also learn to use various IoT devices in real applications.

### Learning Outcomes

- Understand the fundamental concepts of machine learning, security and IoT.
- Identify deep learning and privacy preserving machine learning models, IoT platforms.
- Implement various security techniques for IoT and machine learning applications
- Understand current research trends and developments in the field of machine learning, security and IoT
- Explore on Interacting with digital outputs with C/ Python.

### Syllabus

**Theory** **(15 Hours)**

Basic introduction to IoT, IoT- devices and related security, IoT communication protocols, principles of security, Vulnerability in IoT, CIA triad, Viruses and their types, Machine learning principles, Deep learning, CNN and other models. Concepts of privacy preservation, privacy preserving machine learning models.

**Practicals:** **(105 Hours)**

- Implementing IoT devices for various sensing applications
- Training deep learning models on sensed data
- Implementing IoT communication protocols
- Designing and testing IoT based systems
- Implementing IoT in wearables/ healthcare systems
- Using Python based application for IoT device control**.**
- Implementing basic deep learning models
- Implementing Privacy Preserving Machine Learning (PPML) models on available data

**Essential/ recommended Readings:**


- "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" by David Hanes, Gonzalo Salgueiro, Patrick Grossetete
- "Building IoT Projects with Raspberry Pi and Python" by Matthew Poole
- "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron
- "Machine Learning Yearning" by Andrew Ng
- Adrian McEwen, Hakim Cassimally, ―Designing the Internet of Things‖, John Wiley and Sons, 1st Edition, 2014
- Matt Richardson, Shawn Wallace, ―Getting Started with Raspberry Pi‖, O'Reilly (SPD), 3rd Edition, 2014.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -3 (DSE-3)
## V.5.9. Integral Transform: Applications to Digital Signal Processing

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit-distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Integral Transforms: Applications to Digital Signal Processing, DSE 3, V. 5.9** | **4** | **1** | **0** | **3** | **12th Pass with Maths** | **Calculus, Linear Algebra, Differential equations** |

### Learning Objectives

Signal processing is, in a sense, application of various mathematical tools that primarily consist of Fourier Transforms, Laplace Transforms and $z$ – Transforms. This is a practical-based course and students will:

- learn to utilize integral transformations to solve and analyze problems in digital signal processing
- comprehend and deploy signal processing techniques in an applied environment
- be able to design different types of filters

**Learning outcomes**

- Identification, understanding and differentiation between discrete time system and continuous time system
- Be able to apply mathematical tools – Laplace transform, *Z* transform and Fourier transform to various signals
- Implementation different signal types on matrix based numerical based software
- Designing different low pass, band pass and high pass filters
- Reconstruction of signal from its samples using natural sampling

**Syllabus**

**Theory – (15 Hours)**

LTI system; Convolution; Impulse response representation of LTI system; Fourier Series and Fourier coefficients; Complex exponential function; Fourier Transforms and their basic properties; Some Fourier transform pairs, Nyquist Sampling theorem

**Practicals – (105 Hours)**

- Representation of elementary signals (periodic and non-periodic)
- Basic operations on signals
- MATLAB implementation of different signal types
- Output of convolution of two signals
- Impulse response of an LTI system
- Simulations of difference equations
- Frequency response of LTI system from impulse response
- Representation of DTFS and FS of a signal
- Frequency response of LTI system described by a differential or difference equation
- Relating DTFS to DTFT
- Transform analysis of LTI system
- Computational structures for implementing discrete time LTI systems
- FIR & IIR Filter Implementation using the DSP Processors.
- Sampling theorem and reconstruction of signal from its samples using natural sampling

**Essential/ Recommended readings:**


- C. L. Byrne, “Signal Processing: A Mathematical Approach”, 2 Ed., CRC Press, 2015.
- Haykin, S. and Van Been, B., “Signals and Systems” 2 Ed., John Wiley & Sons, 2003.
- Sundararajan, D., “A Practical Approach to Signals and Systems”, Wiley, 2008.
- Padmanabhan, K., Ananthi, S. and Vijayarajeswaran, R., “A Practical Approach to Digital Signal Processing”, New Ag International, 2003.

# B. Tech. (Information Technology and Mathematical Innovations), Semester-VI

| Paper No. | Interactive Learning Modules (Paper Title) | Credits | | | |
|---|---|---|---|---|---|
| | | L | T | P | Total |
| VI.1 DSC 16 | Numerical Methods for Computational Mathematics | 2 | 0 | 2 | 4 |
| VI.2 DSC 17 | Information Security | 3 | 1 | 0 | 4 |
| VI.3 DSC 18 | Artificial Intelligence | 3 | 1 | 0 | 4 |
| VI.4* GE 6 | VI.4.1 e-Business: Organisation and Strategy | 2 | 0 | 2 | 4 |
| | VI.4.2 Control Systems | | | | |
| | VI.4.3 Genomics and Proteomics | | | | |
| VI.5** DSE 4 | VI.5.1. Mathematical Modeling & Simulation# | 0 | 0 | 4 | 4 |
| | VI.5.2. Computational Fluid Dynamics (CFD)# | | | | |
| | VI.5.3. Technology based solutions of societal issues# | | | | |
| | VI.5.4. Medical Imaging Techniques# | | | | |
| | VI. 5.5. Computational Analysis of OMICS data | | | | |
| | VI.5.6. Virtual Reality# | | | | |
| | VI.5.7. Complex Systems | | | | |
| | VI. 5.8 Research and Methodology | | | | |
| VI.6*** SEC 6 | Any one from the pool of SEC | - | - | - | 2 |
| VI.6*** IAPC 4 | Simulation of real-world problems | 0 | 0 | 2 | 2 |
| Grand Total | | | | | 22 |

***Any one GE paper will be opted by students from GE 6 papers in paper VI.4.**
****Any one DSE paper will be opted by students from DSE 4 papers in paper VI.5.**
*****Student will either opt for SEC 6 or choose internship (IAPC 4) in paper VI.6.**

**# These papers are also being offered in semester IV**
**Key: L: Lecture, T: Tutorial, P: Project/Practical/Internships**

**SEMESTER-VI**

## DISCIPLINE SPECIFIC CORE COURSE – 16 (DSC-16)
## VI.1. Numerical Methods for Computational Mathematics

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | |
| Numerical Methods for Computational Mathematics DSC 16, VI.1 | 4 | 2 | 0 | 2 | 12th Pass with Mathematics | Linear Algebra, Programming Language, Ordinary Differential Equations |

### Learning Objectives

In practical scenarios, the governing mathematical models are usually too complex to be solved analytically and numerical techniques become the only way out to approximate the solutions. This paper aims to teach the student solutions of nonlinear equations in one variable with error analysis, interpolation and approximation, numerical differentiation and integration, direct methods for solving linear systems, numerical solution of ordinary differential equations. By the end of this paper, students should have the ability to compare the computational methods for advantages and drawbacks and choose the suitable computational method among several existing methods for underlying physical problems. In this paper, students will write codes in MATLAB/C/C++ for implementation of numerical methods.

### Learning outcomes

After completing this course, student should be able to;

- Understand the need of numerical techniques and their importance in real situations
- Learn different techniques of solving non-linear equations such as Bisection method, Newton Raphson method, Regula Falsi method, Secant method & Iterative methods
- Analyze errors associated with these methods and their rate of convergence
- Learn Gauss elimination, Gauss seidel, LU decomposition methods for solving system of linear equations with pivoting concepts

- Learn polynomial interpolation, linear and cubic spline interpolations, analyze errors of interpolation
- Conceptualize numerical integration and errors associated with it.
- Learn Euler's method and Runge-Kutta method for numerical solution of differential equations
- Write programs of all these numerical methods in MATLAB/C/C++

## SYLLABUS

**Unit I:** Solving Nonlinear Equations - Graphical method - Bracketing and Non-bracketing approach. - Bisection, Method of false position, Iterative method, Newton-Raphson method and Secant method - Errors and rate of convergence **(8 Hours)**

**Unit II:** Matrix notation of a system of linear equations - Gaussian elimination and Gauss-seidel method – Pivoting - Row-echelon form - LU factorization **(6 Hours)**

**Unit III:** Polynomial interpolation - Forward, Backward and Divided differences - Piecewise linear and Cubic Spline interpolation - Errors in interpolation **(6 Hours)**

**Unit IV:** Newton-Cotes Integration Formula - Trapezoidal and Simpson's rules - Gaussian quadrature, Euler, Modified Euler and Runge-Kutta methods for solution of differential equations - Power method, QR method for Eigen Value problems **(10 Hours)**

## Practicals- **(60 Hours)**

- Writing MATLAB/C/C++programs for finding root of the equations using Bisection,Newton- Raphson, Iterative and Secant methods
- Writing MATLAB/C/C++programs for solving system of linear equations (Gaussian Eliminations, Gauss Jacobi & Gauss Seidel Method)
- Writing MATLAB/C/C++ programs for interpolation, forward, backward and divided difference
- Writing MATLAB/C/C++ programs for methods of numerical integration
- Writing MATLAB/C/C++ programs for Euler and Runge-Kutta methods.

**Essential/recommended readings**


- Applied Numerical Analysis, C. F. Gerald and P. O. Wheatly, Pearson Education India, 2007.
- Introduction to Applied Numerical Analysis, R. W. Hamming, Dover Publications, 2012.
- Elementary Numerical Analysis- An Algorithmic Approach, S. D. Conte and Carl de Boor, McGraw-Hill, 1980.
- Numerical Recipes: The Art of ScientificComputing,3rd Edition, William H.Press, Saul A.Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press, 2007

## DISCIPLINE SPECIFIC CORE COURSE – 17 (DSC-17)
## VI.2. Information Security

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Information Security, DSC-17, VI.2.** | **4** | **3** | **0** | **1** | **12th Pass with Mathematics** | **Programming Language** |

### Learning Objectives

This course will discuss the fundamentals of cryptography and its application to network security. Understand network security threats, security services, and countermeasures. Understand vulnerability analysis of network security. Acquire background on hash functions; authentication; firewalls; intrusion detection techniques. Gain hands-on experience with programming and simulation techniques for security protocols. Understand the tradeoffs and criteria/concerns for security countermeasure development. Apply methods for authentication, access control, intrusion detection and prevention. Identify and mitigate software security vulnerabilities in existing systems.

### Learning outcomes

After completing this course, student should be able to;

- Understand and explain the risks faced by computer systems and networks.
- Identify and analyze security problems in computer systems and networks.
- Explain how standard security mechanisms work.
- Develop security mechanisms to protect computer systems and networks.
- Write programs that are more secure.
- Use cryptography algorithms and protocols to achieve computer security.

### SYLLABUS

**Unit I:** Introduction to Information Security, CIA, Conventional Cryptographic Techniques: Substitution and transposition ciphers, One Time Pad. **(12 Hours)**

**Unit II:** Block cipher and Stream Cipher, Steganography**:** Symmetric and Asymmetric Cryptographic Techniques: DES, AES, RSA algorithms, Authentication and Digital Signatures, Secure Hash function. **(13 Hours)**

**Unit III**: Program Security: Nonmalicious Program errors – Buffer overflow, Incomplete mediation, Time-of-check to Time-of- use Errors, Viruses, Trapdoors, Salami attack, Man-in-the-middle attacks, **(10 Hours)**

**Unit IV:** Threats in networks, Network Security Controls – Architecture, Wireless Security, Honeypots, Traffic flow security, Firewalls, Types of Firewalls, Personal Firewalls, IDS, Email Security – PGP,S/MIME **(10 Hours)**

**Practicals:** **(30 Hours)**

- Implementing trans-positional ciphers.
- Implementing substitution ciphers
- Using block and stream ciphers from various available libraries
- Implementing Al-Gamal Key sharing algorithm
- Implementing and using AES/DES and RSA algorithm
- Understanding authentication practically
- Simulating attacks on system

**Essential/recommended readings**


- Security in Computing, Fourth Edition, by Charles P. Pfleeger, Pearson Education
- Cryptography And Network Security Principles And Practice, Fourth or Fifth Edition, William Stallings, Pearson
- Modern Cryptography: Theory and Practice, by Wenbo Mao, Prentice Hall
- Network Security Essentials: Applications and Standards, by William Stallings. Prentice Hall

## DISCIPLINE SPECIFIC COURSE -18 (DSC 18)
## VI. 3: Artificial Intelligence

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical / Practice | | |
| **Artificial Intelligence DSC 18, VI.3** | **4** | **3** | **0** | **1** | **12th Pass with Mathematics** | **Programming, Data Structure, Design and Analysis of Algorithms** |

### Learning Objectives

The objective is to introduce the basic principles and techniques of Artificial Intelligence. The course provides a theoretical foundation for variety of concepts in the field of artificial intelligence. To enhance the practical understanding of AI concepts, the course expects problem-solving projects as a 'hands-on' approach and avenue for exploration and creativity.

### Learning outcomes

Upon completion of this course, the student will be able to:

- Learn the fundamentals of artificial intelligence.
- Learn to problematize the problems and solve them.
- Understand and implement search and adversarial (game) algorithms.
- Understand mathematical models such as belief networks and apply them to a range of AI problems.
- Have a glance at machine learning algorithms and extracting knowledge models from data.
- Understand the fundamentals of Machine learning and Reinforcement learning.

### SYLLABUS

**Unit I:** Philosophy of Artificial Intelligence, Intelligent Agents **(9 Hours)**

**UNIT II:** Problem-solving, Search techniques, Constraint satisfaction, Game playing, Automated Planning **(9 Hours)**

**UNIT III:** Knowledge Representation and Reasoning through Logic, Bayesian Networks, Markov Decision Processes **(12 Hours)**

**UNIT IV:** Machine Learning, and Reinforcement Learning **(15 Hours)**

**Practicals-** **(30 Hours)**

- Implementation of problem-solving and search techniques.
- Implementation of hill climbing and its variations.
- Implementation of genetic algorithm search.
- Implementation of heuristics search techniques.
- Implementation of machine learning algorithms and their applications.
- Development of artificial intelligence projects.

**Essential/recommended readings**


- Russell, S., & Norvig, P. (2021). Artificial intelligence: A modern approach, global edition 4th. Foundations, 19, 23.
- Poole, D. L., & Mackworth, A. K. (2010). Artificial Intelligence: foundations of computational agents. Cambridge University Press.
- Kulkarni, P., & Joshi, P. (2015). Artificial intelligence: Building intelligent systems. PHI Learning Pvt. Ltd.
- Artificial Intelligence, 3rd Edition. R. Elaine, K. Knight, S. Nair, Tata McGraw-Hill, 2009.
- Bishop, C. M., & Nasrabadi, N. M. (2006). *Pattern recognition and machine learning* (Vol. 4, No. 4, p. 738). New York: Springer.
- Winston, Patrick Henry, Artificial Intelligence. 3rd ed. Addison-Wesley, 1992.
- Kevin P. Murphy and Robert R. Reitano, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.

# COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

**NOTE: The core papers offered in the B.Tech. Course at CIC are Mathematics and Information Technology. Therefore, the students will choose GE offered by Physics, Chemistry, Management and Computational Biology faculty members of CIC.**

## GENERIC ELECTIVES (GE-6)
## VI. 4.1. e-Business Organization and Strategy

### Credit distribution, Eligibility and Pre-requisites of the Course

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| e-Business: Organization and Strategy, GE-6, VI. 4.1. | 4 | 2 | 0 | 2 | 12th Pass | Basic understanding of consumer behaviou | Management Faculty of CIC |

### Learning Objectives

The core objective of this subject is to provide students with a comprehensive understanding of the managerial as well as technical aspects of e-business, i.e., what is e-business and how it works? The contemporary theories and new business models will be discussed as a theory to form a strong basis for practice. The participants will develop insights for the effective designing and development of e-business strategy as a channel of communication or channel of distribution or both. The analytical ability of students will be enhanced via analytical tool for understanding customer behaviour towards E- business.

### Learning Outcomes

**After completing this course, student should be able to:**

- Understand the dynamic business environment and its elements
- Understand different business models and their application.
- E-commerce architecture and its platforms.

- Understand the dynamics of E-brand trust via ICT.
- Plan e- marketing tools and Web analytics through KPI's.
- Analyse important strategic elements of e- supply chain management, e-customer relations management, e-procurement.
- Perform predictive analysis, customer analysis, pricing, marketing, and over-all retail analytics application in different online retail sectors.
- Envision financial dynamics and cost analysis in website management for a start-up.

## SYLLABUS

**Unit I:** Evolution of e-business and transitions-E-commerce and internet penetration, Web 1.0, Web 2.0, Web 3.0, E-business models & organisation structure- Indian and Global trends, Business responsiveness during crisis, supply chain disruptions and management, Opportunities for Innovations. **[10 hours]**

**Unit II:** E-business and consumer behaviour- Consumer complex buying behaviour patterns, sentiment analysis, consumer online engagement tools for reviews and managing UGC (User generated content), E-Brand Trust, and Security and role of Information Systems and various approaches in ICT Systems **[10 hours]**

**Unit III:** Perspectives and requirements for starting online business: Revenue and resources, Processes associated with managing website development, ICT in types of businesses such as B2B and B2C. SEO's, measuring success, On page and off page search engine optimisation, Customer acquisition, customer experience, conversion and retention. **[10 hours]**

## Practicals: **(60 Hours)**

- Hands on training will be provided by experts from academia and industry regarding different E-business tools for analysing consumer behaviour and building robust advertising strategies
- Predictive analysis using Python, performing (Recency-frequency-monitory) RFM analysis for creating customer clusters.
- Churn Prediction analysis
- Market Basket analysis
- Web analytics- Sentiment analysis via social media such as Google ads, twitter, Facebook and Instagram.
- Case study discussion on real life cases of the companies that exploited the competitive advantage of IT to leverage their growth and expansion.
- Case study discussion on innovative e-business evolved such as online grocery stores, fashion retail which emerged out of market space and other concepts.

**Essential/ recommended readings:**

- Internet Business Models and Strategies: Text and Cases, A. Afuah and C. L. Tucci, McGraw-Hill., 2003.
- Information Technology and the Corporation of the 1990s: Research Studies, T. J. Allen and M.S. Morton, Oxford University Press, New York 1994.
- Strategies for e-Business: Creating Value through Electronic and Mobile Commerce, T. Jelassi and A. Enders, Prentice Hall, 2005.
- Competitive Advantage: Creating and Sustaining Superior, Performance, Michael E. Porter, The Free Press, New York, 1985.
- E-Learning Tools and Technologies, Horton and Horton, Wiley Publishing, 2003

## GENERIC ELECTIVES (GE-6)
## VI. 4.2. Control Systems

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Control Systems GE-6, VI. 4.2 | 4 | 2 | 0 | 2 | 12th Pass with Mathematics | Linear Algebra, Differential equations | Physics/ Electronics Faculty of CIC |

**Learning Objectives**

This interactive learning module intends to provide capabilities and basic understanding of functionality and control of a system or a device. It will emphasize on the conceptual know-how of the behavioral aspects and mechanism of different machines, equipment or a system, their manageability, efficiency and performance as per controlled parameters.

**Learning outcomes**

After completing this course, student should be able to;

- Understand the building blocks of basic and modern control systems.
- Understand the concept of stability analysis of control systems in both time and frequency domain.

- Understand the concept of MATLAB and SIMULINK toolbox to simulate the control systems.
- Perform comparative study of electrical systems using simulation software - Multisim, Eagle, LTSpice and experimental set-up.
- Understand the complex mathematical operations associated with building blocks of various control systems.

## SYLLABUS

**Unit I:** Introduction to Control Systems - Analysis and design objectives - The design process - Classification and modeling of control systems **(6 Hours)**

**Unit II:** Modeling in the frequency domain - Modeling in the time domain - Time response - Reduction of multiple subsystems **(6 Hours)**

**Unit III:** Signal flow graphs - Mason's rule - Routh Hurwitz Criterion - Steady state errors - Root locus techniques - Frequency Response Techniques **(8 Hours)**

**Unit IV:** Root Locus and its Applications -– Design via state space -– Non-linear analysis – Controller and its applications -– Case Studies **(10 Hours)**

## Practicals – **(60 Hours)**

The following explorations would be carried out on matrix based numerical mathematics software:

- Designing the model of a DC motor
- Design of controllers for speed and position control
- Compensator design
- Realization of logic gates through diodes and resistors
- Verification of Boolean algebraic functions through digital IC gates
- Design of half/full adder and sub tractor circuits
- Design of shift registers using flip-flops
- Circuit simulation
- State space model design
- Design of temperature controller
- Hands on experiments with PID controller
- Innovation Project

## Essential/recommended readings


- Control Systems Engineering, 6th Edition, Norman S Nise, Wiley, 2011.
- Linear Control Systems with MATLAB Applications, 11th Edition, B. S. Manke, Khanna Publishers, 2013
- Discrete-Time Control Systems, K. Ogata, Prentice Hall, 1995.
- Control Tutorials for MATLAB and Simulink, W. Messner and D. Tilbury, Addison-Wesley, 1998.

## GENERIC ELECTIVES (GE-6)
## VI. 4.3. Genomics and Proteomics

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Prerequisite of the course (if any) | Dept. offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Genomics and Proteomics GE-6, VI.4.3 | 4 | 2 | 0 | 2 | 12th Pass | Basic knowledge of biological sciences | Chemistry / Biology Faculty of CIC |

### Learning Objectives

**This module is designed to:**

- Introduce students to basic RDT techniques
- Introduce students to basic tools of genomics and proteomics
- Introduce students to building and analyzing networks involving complex biological data.

### Learning outcomes

**After studying this course, the students will be able to:**

- Design primers for PCR
- Well-versed in gene cloning techniques
- Will develop skills in understanding the advancement of the genomic and proteomics branches of Sciences and their importance in manipulating genome and proteome.

### SYLLABUS

**Unit I: Basics of gene cloning** **(8 Hours)**

Introduction to Recombinant DNA technology, Isolation of DNA, PCR amplification, Types of PCR, Restriction digestion, Cloning and expression vectors, Cloning, Expression, Purification of expressed proteins, DNA libraries and Screening

**Unit II: Genome analysis** **(8 Hours)**

Genome sequences and database, Discovery of new genes and function, Early DNA sequencing efforts: Maxam & Gilbert Method, Sanger Di-deoxy method, Fluorescence method, shot-gun approach, NGS: different methods and principles, Genome libraries, expressed sequenced tags (ESTs)

**Unit III: Applied Genomics** **(8 Hours)**

Genotyping tools: DNA Chips, Diagnostic assays, Diagnostic services. Functional genomic studies with model systems such as Drosophila, Yeast and C. elegans, Interference RNA, RNA silencing, SiRNA: Applications in Functional genomics, Medicine and Gene Knockdown. Gene Editing - Crispr Cas9

**Unit IV: Applied Proteomics** **(6 Hours)**

Large-scale preparation of proteins and peptides, Synthesis of peptides, Use of peptides as probes Two-hybrid interaction screens, Mass-spec based analysis of protein expression. "Protein Chip" - interactions and detection techniques, Two-dimensional PAGE for proteome analysis, Detection of proteins on SDS gels, Protein cleavage, Edman protein micro-sequencing, Automation in proteomics, Applications of proteome analysis to drug development and toxicology, Phage antibodies as tools for proteomics.

**Practicals-** **(60 Hours)**

- Isolation and analysis of plasmids
- Expression of proteins as inclusion bodies
- Isolation and refolding of the inclusion bodies
- Agarose Gel Electrophoresis
- SDS PAGE analysis
- Primer design
- Polymerase Chain Reaction (PCR)
- Restriction Digestion
- Cloning Strategy (Introductory Gene Cloning)

**Essential Readings**


- Principles and Techniques of Biochemistry and Molecular Biology, Wilson & Walker, Cambridge University Press, 2010
- Principles of Gene Manipulation and Genomics, Primrose and Twyman, Wiley-Blackwell 2013

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.1. Mathematical modelling & Simulation

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Mathematical modeling & simulation# DSE-4, VI.5.1** | **4** | **0** | **0** | **4** | **12th pass with Maths** | **Linear Algebra, Differential Equations** |

**# This course will also be available to the students in semester IV**

### Learning Objectives

This interactive learning module intends to provide capabilities and basic understanding of system modelling and simulation performance. It will emphasis on analysis of dynamical behavior of physical, electrical, mechanical, social, biological, chemical, and financial systems along with applications in engineering and other applied sciences. The simulation will be done with the MATLAB software platform.

### Learning outcomes

- After completing this course, student should be able to;
- Understand the mathematical and computational tools for modelling and simulation of various systems.
- Apply basic concepts of fractional calculus.
- Identify, model analyze, and simulate various systems using simulation tools.
- Know how the simulation help to analyze system graphically.
- Describe the behavior of different physical and virtual systems.

### Syllabus

**Practicals –** **(120 Hours)**

- Modeling of integer and non-integer systems
- Introduction to basic simulation tools
- Simulation performance of integer and non-integer systems
- Chaotic behavior of integer and non-integer systems
- Parameter optimization to improve the efficiency of the system
- Model validation and performance analysis with data
- Innovation Project

### Essential/recommended readings


- Theory of modeling and simulation, Zeigler B.P., Praehofer. H., Kim I. G., 2nd Edition. Academic press, 2000.
- Theory of Fractional Dynamic Systems, Lakshmikantham, V., Leela, S., Vasundhara Devi, J. Cambridge Academic Publishers, Cambridge, 2009.
- Fractional-order nonlinear systems: modeling, analysis and simulation, Petras, I., SpringerVerlag Berlin Heidelberg, Germany, 2011.
- Chaos: An Introduction to Dynamical Systems, K.T. Alligood, Sauer, Tim D., Yorke James Springer, 1996.
- Nonlinear Dynamics and Chaos, Strogatz, S. Reading, MA: Addison-Wesley, 1994.
- Optimization and Dynamical Systems, Helmke U., Moore J. B, SpringerVerlag, 1993.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.2. Computational Fluid Dynamics (CFD)

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Computational Fluid Dynamics# (CFD), DSE-4, VI.5.2** | **4** | **0** | **0** | **4** | **12th Pass With Maths** | **Calculus, Linear Algebra & Differential Equations** |

**#This course will also be available to the students in semester IV**

### Learning Objectives

This interactive practical paper aims to enable the students to visualize different types of problems of flow and heat transfer in various fields. Blood flow within arteries, biological tissues, heat transfer within biological tissues, flow within circular pipes, flow within an aquifer are some of the important application of CFD. In this paper, students will visualize CFD models, mathematical analysis of these visualizations, simulate them numerically using mathematical softwares such as ANSYS, COMSOL and post process the obtained numerical results.

## Learning Outcome

After completing this paper, students will be able;

- Visualise and implement mathematical models of flow and heat transfer problems in different applications.
- Implement existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design of UDF based problem specific modules in ANSYS/COMSOL
- Validate their numerical results with experimental data (if available) for suggesting new designs.

## Syllabus

**Practicals - (120 Hours)**

- Governing equations for CFD: The continuity, momentum and energy equations with their physical interpretation
- Interpretation of different set of flow conditions such as inflow, outflow, no slip boundary etc as per problem requirement.
- CFD mesh generations, structured and unstructured mesh, mesh refinement (local & global), adaptive mesh.
- Implementation of existing CFD based modules in ANSYS/COMSOL for simulation purpose.
- Design and modification of existing modules using UDF (User defined functions) in ANSYS/COMSOL as per the problem requirement.
- Post-processing of numerically simulated results

## Essential/ Recommended Readings:


- Computational Fluid Dynamics: A practical Approach (2019) by Jiyuan Tu, Guan Yeoh, Chaoqun Liu, 2nd Edition, Publisher: Butterworth-Heinemann.
- Computational Fluid and Particle Dynamics in the Human Respiratory system (2012) by Jiyuan Tu, Kiao Inthavong, Goodarz Ahmadi, Biological and Medical Physics, Bio-medical Engineering, Publisher: Springer.
- Multiphysics Modelling using COMSOL: A First Principle Approach (2011), by Roger W. Pryor, Jones and Bartlett Publishers, London, Singapore.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.3. Technology based solutions of societal issues

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Technology based solutions of societal issues, DSE-4, VI.5.3.** | **4** | **0** | **0** | **4** | **12th pass** | **Programming Fundamentals, Basic knowledge of biology.** |

**#This course will also be available to the students in semester IV**

### Learning Objectives

This course is designed for students to give them hands-on experience of working on interdisciplinary research problems, which may have direct impact or relevance for the linkage of society and technology. This will broaden their horizon regarding the identification of an issue and then step by step way of solving the same, either theoretically or experimentally by acquiring the required technology-based skill-sets.

### Learning outcomes

After completing this course, student should be able to;

- Identify a research problem related to a societal issue, which may be solved using technology
- Acquire the required technical skill-sets, which will be needed for solving such problems
- Get the hands-on training for working on real societal issues requiring technology-based interventions, so that students can become more sensitive and responsible for solving such issues

### Syllabus

**Practicals –** **(120 hours)**

- Developing an understanding related to societal issues specifically in the sectors of water, food, electricity, textiles, housing, energy, defense and human health etc., which may require a technology-based intervention
- Identification of a problem as per interest of the student, and solving it using innovative and interdisciplinary approaches

- Working on problems based on artificial intelligence-based biosensors, Electrochemical biosensors, wearable biosensors etc. for various applications related to society
- Building machine learning models on various datasets specially related to health issues for the identification, diagnosis or prediction of the disease
- Computational modeling/ simulation of nanoparticles and their usage in drug delivery applications for various diseases. Examples can be like neuro-simulation of drug-loaded nanoparticles for understanding the pathway for diseases like mental depressive disorders.

### Essential/recommended readings

- Sensing and Artificial Intelligence Solutions for Food Manufacturing; Editors: Charles Oluwaseun Adetunji, Daniel Hefft, CRC Press
- Mathematical Modeling of Biosensors by Romas Baronas, Felikas Ivanauskas, Juozas Kulys, (2021); Springer International publishing
- Biosensors and Nanotechnology: Applications in Health Care Diagnostics (2017), Editor: Zeynep Altintas; Wiley Publishers
- Research papers/ Reviews from peer reviewed reputed journals, related to the identified problem/ issue

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.4. Medical Imaging Techniques

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Medical Imaging Techniques#, DSE-4, VI.5.4** | **4** | **0** | **0** | **4** | **12th Pass** | **Basic knowledge of python** |

**#This course will also be available to the students in semester IV**

### Learning Objectives

This practical paper is designed to provide hands on experience to build data driven module for computer vision, with applications in medical image analysis. This practical paper enables the students to build deep learning architecture, such as filters, activation functions, loss functions; regularization techniques such as e.g. batch normalization and dropout. Student can implement

different non-linear optimization algorithms that are used when training the medical imaging networks on different imaging tools.

## Learning outcomes

- Training and validation of image dataset, classification and regression, supervised and unsupervised learning, bias and variance, loss function, generalization error, accuracy, precision, to medical image dataset.
- Can implement deep learning parameters, such as e.g. depth, learning rate, hyper parameter, overtraining and regularization in softwares.
- Implementation of different deep learning architecture for classification and segmentation of diagnosis of various diseases.
- Can simulate hybrid deep learning architecture and models used in medical imaging.

## Syllabus

**Practicals -** **(120 Hours)**

- Implementation of basic Medical imaging tools.
- Feature extraction, segmentation, systematic evaluation and validation on medical image datasets using data driven architectures.
- Designing different machine learning and deep learning based models for segmentation and classification of medical imaging datasets.
- Performance analysis of different deep learning architecture in terms of statistical parameters.
- Case studies on some recent advances in analysis of retinal, CT, MRI, ultrasound and histology images.

## Essential/recommended readings


1. The Handbook of Medical Image Perception and Techniques, by Ehsan Samei and Elizabeth A. Krupinski, second edition, Publisher Cambridge University Press.
2. Medical Imaging by DS Guru, K.C. Santosh, Nilanjan Dey, Sameer Antani, Publisher CRC Press.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.5. Computational Analysis of OMICS data

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Computational Analysis of OMICS data DSE 4, VI. 5.5.** | **4** | **0** | **0** | **4** | **12th Pass** | **One programming language, Basic knowledge of statistics and biology.** |

### Learning Objectives

**This module is designed to:**

- Introduce students the basic tools and processes of genetic engineering
- Introduce students to basic tools of genomics and proteomics
- Introduce students to building and analyzing networks involving complex biological data.

### Learning outcomes

**After studying this course, the students will be able to:**

- develop skills in understanding the advancement of the genomic and proteomics branches of Sciences and their importance in manipulating genome and proteome.
- handle genome and proteome data.
- do mathematical prediction of high throughput data

### SYLLABUS (120 hours)

**Practicals-**

1. Computational analysis of genomics / proteomics / Metabolomics data
2. Large scale genome sequencing strategies and interpretation of results
3. Handling microarray data, SNPs and OMIMs
4. Transcriptome Analysis: Databases and basic tools: Gene Expression Omnibus (GEO)
5. Array Express, SAGE databases
6. RNA Sequencing
7. Active site prediction
8. Machine learning tools, such as Neural network, SVM etc.

9. Protein MS applications: Identifying unknown proteins by peptide mass fingerprinting; de novo sequencing of peptides from fragment ion spectra obtained by tandem MS; Protein arrays: basic principles.
10. Using bioinformatics tools for proteomics: SEQUES, MASCOT etc.

**Essential Readings**


- Gary Hardiman, Ed, Systems Analytics and Integration of Big Omics Data, 2020, SBN 978-3-03928-744-4, https://doi.org/10.3390/books978-3-03928-745-1
- Bioinformatics for Omics Data Methods and Protocols, Edited by Bernd Mayer, emergentec biodevelopment GmbH, Vienna, Austria, Humana Totowa, NJ, 2011, 978-1-61779-027-0Published: 03 March 2011
- Omics Approaches, Technologies and Applications, Integrative Approaches For Understanding OMICS Data, Edited by Preeti Arivaradarajan, Gauri Misra, 2018, Springer Nature, https://doi.org/10.1007/978-981-13-2925-8
- Big data in OMICS and Imaging, Momiao Xiong, Chapman and Hall/CRC, 2017.


## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.6. Virtual Reality

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Virtual Reality#, DSE 4, VI. 5.6** | **4** | **0** | **0** | **4** | **Class XII pass with Maths** | **C++** |

**#This course will also be available to the students in semester IV**

### Learning Objectives

The objective of this course is to provide a detailed understanding of the concepts of Virtual Reality and its applications

### Learning outcomes

At the end of the course, the students will be able to:

- Understand geometric modelling and Virtual environment.
- Be able to do 2D and 3D geometrical modelling
- Develop Virtual Reality applications.

**Practicals -** **(120 Hours)**

The course will be conducted completely on a hands-on mode and project-based learning. The basic concepts will be explained and each concept will be augmented by small tasks in UNITY. Animations and physical simulations will be introduced to the students through an appropriate Virtual environment. Following tasks will be covered in the lab:

- Introduction to the Virtual environment
- Introducing frame of reference and modelling transformations
- Animation in virtual environment – projectile motion, flight/ car simulation, Ferris wheel, pendulums, etc.
- Visualising Human Anatomy/ geographical regions/ environment/ monuments in the VR environment
- Modelling a store/ classroom/ office/ mall in VR

**Essential/recommended/ suggested readings**

- Virtual Reality Systems, John Vince, Pearson Education India, 2002. https://all3dp.com/2/blender-3d-printing-tutorial/
- Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, Morgan Kaufmann, 2018
- Virtual Reality, Samuel Greengard, MIT Press, 2019.
- Virtual and Augmented Reality, Paul Mealy, Wiley, 2018.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.7. Complex Systems

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Complex Systems, DSE 4, VI. 5.7** | **4** | **0** | **0** | **4** | **12th Pass with Maths** | **Programming languages, data Structure, Algorithm design and analysis, Computer Neworks, Discrete Mathematics** |

## Learning Objectives

The objective of this course is to provide a practical and detailed understanding of the complex systems which can be found in various fields and disciplines, like sociology, political systems, biology, and economics etc.

## Learning outcomes

At the end of the course, the students will be able to:

- to understand the basics of complex systems and their importance.
- to recognise complex systems related to societal, environmental, engineering and scientific problems and to learn their basic features;
- to introduce a problem-solving approaches for complex systems.
- to get hands-on experience in studying and solving complex systems problems.

## Syllabus

**Practicals-** **(120 Hours)**

The course will be conducted completely on a hands-on mode and project based learning. The basic concepts will be explained and associated real world challenging problems will be identified.

- Practical exposure to complex systems in domains like global climate, organisms, the human brain, infrastructure such as power grid, transportation or communication systems, complex software and electronic systems, social and economic organizations (like cities).
- Experiment to model dependencies, competitions, relationships, or other types of interactions between their parts or between a given system and its environment.
- Practicals on problem solving on nonlinearity, emergence, spontaneous order, adaptation, and feedback loops, among others.
- Practical on network approach a solution to complex problems where the nodes represent the components and links to their interactions.
- Students will be exposed to the practical application of complex systems concepts and problem-solving approaches on such real world problems.

**Essential/recommended/ suggested readings**


- Bar-Yam, Y. (2019). Dynamics of complex systems. CRC Press.
- Cilliers, P. (2002). Complexity and postmodernism: Understanding complex systems. Routledge.
- Dekker, S. (2016). Drift into failure: From hunting broken components to understanding complex systems. CRC Press.

## DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4)
## VI.5.8. Research Methodology

### CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| Research Methodology, DSE 4, VI. 5.8 | 4 | 0 | 0 | 4 | 12th Pass | NIL |

### Learning Objectives:

The course is designed to make students understand about what, why and how to conduct research includes nature and purpose of research, identifying research problems, building research design, appropriate selection of research tools and methods for data analysis and also developing the base of future researches

### Learning Outcomes

After completing the course, student should be able to

- Identify a research problem
- Formulate hypotheses
- In depth literature review
- Plan research design
- Use research tools and techniques, methods of analysis
- Ethics in research
- Communication skills

**Practicals –** **(120 Hours)**

- Art of reviewing research articles, identification of research gap and finding research problems, framing research objectives, Outline for research proposal.
- How to conduct an exploratory study, Experiments, Quantitative and qualitative study based on research questions and objectives, Data coding and entry to the software, Analysis of data through various tools, applications and research techniques such as regression and correlation, Hypothesis testing and inferences
- Familiarity with data collection software, E-resource library system with journals, books and publications, Usage of the data analysis and software.

- Directing students to follow report writing conventions, citations, acknowledgements, checking originality of the work vis plagiarism software and abiding research ethics, Presentation of work, how to get the research work published in a reputed journal.

**Suggested Readings:**


- Kitsakorn Locharoenrat, Research Methodologies for Beginners, Pan Stanford Publishing Pte. Ltd., Singapore, 2017.
- C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2004, ISBN 8122415229, 978812241522.
- Kumar R. Research Methodology: A step by step Guide for Beginners (2010) 3rd ed., Pearson Education. (ISBN-13: 978-1849203012)
- Relevant study material from ACM, IEEE, Elsevier, Springer
- Levin, R. I and D.S. Rubin, Statistics for Management, Prentice Hall of India.
- Aczel, Amir D., and Sounderpandian, J., Complete Business Statistics, Tata McGraw Hill Publishing