A.C.-03.08.2022
Appendix-112

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*** **(6 lectures)**
Forms of energy and conversion between different forms of energy.

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

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.