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 L	T	P	Total	Prerequisite of the course
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

SEMSTER – 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