St. Xavier's University, Kolkata

Syllabus for

B. Tech. in Computer Science and Engineering with Artificial Intelligence and Machine Learning (CSE AI-ML)

Course Curriculum

Semester I						
S.No	**Course Type**	**Course Title**	**Hours per week**			**Credits**
			L	**T**	**P**	
1.	BSC	Chemistry	3	1	2	5
2.	BSC	Mathematics-I	3	1	0	4
3.	ESC	Programming for Problem Solving	3	0	2	4
4.	PCC	Computer Organization and Architecture	3	0	4	5
5.	HSMC	Design Thinking	0	0	2	1
6.	HSMC	Universal Human Values: Understanding Harmony and Ethical Human Conduct	2	1	0	3
Total			27			22

Semester II						
S.No	**Course Type**	**Course Title**	**Hours per week**			**Credits**
			L	**T**	**P**	
1.	BSC	Physics	3	1	2	5
2.	BSC	Mathematics-II	3	1	0	4
3.	ESC	Mathematical Concepts for Artificial Intelligence	3	1	0	4
4.	PCC	Data Structure and Algorithms	3	0	4	5
5.	PCC	Discrete Mathematics	3	0	0	3
6.	HSMC	Communicative English	2	0	2	3
Total			28			24

Detailed Syllabus

SEMESTER I

Chemistry

Credit: 5
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Atomic and Molecular Structure	Schrodinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicenter orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.
II	Spectroscopic techniques and applications	Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.
III	Intermolecular forces and potential energy surfaces	Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.
IV	Use of free energy in chemical equilibria	Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and EMF. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Water chemistry. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.
V	Periodic properties	Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.
VI	Stereochemistry	Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

VII	Organic reactions and synthesis of a drug molecule	Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Practical:
The following topics are to be covered:
Choice of 10-12 experiments from the following:

1. Determination of surface tension and viscosity.
2. Thin layer chromatography.
3. Ion exchange column for removal of hardness of water.
4. Determination of chloride content of water.
5. Colligative properties using freezing point depression.
6. Determination of the rate constant of a reaction.
7. Determination of cell constant and conductance of solutions.
8. Potentiometry - determination of redox potentials and EMFs.
9. Synthesis of a polymer/drug.
10. Saponification/acid value of an oil.
11. Chemical analysis of a salt.
12. Lattice structures and packing of spheres.
13. Models of potential energy surfaces.
14. Chemical oscillations- Iodine clock reaction.
15. Determination of the partition coefficient of a substance between two immiscible liquids.
16. Adsorption of acetic acid by charcoal.
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Suggested Books [Latest edition]:

1. Chemistry – I with Lab Manual, Khanna Book Publishing.
2. Engineering Chemistry, by Manisha Agrawal.
3. University chemistry, by B. H. Mahan.
4. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane.
5. Fundamentals of Molecular Spectroscopy, by C. N. Banwell.
6. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan.
7. Physical Chemistry, by P. W. Atkins.
8. A Textbook of Engineering Chemistry, Shashi Chawla.
9. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition http://bcs.whfreeman.com/vollhardtschore5e/default.asp

Mathematics-I

Credit: 4
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Introduction Basic Calculus	Curvature, evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma Functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.
II	Single-variable Calculus (Differentiation)	Rolle's Theorem, Mean value theorems and applications; Extreme values of functions; Linear approximation; Indeterminate forms and L' Hospital's rule.
III	Sequences and series	Limits of sequence of numbers, Calculation of limits, Infinite series; Tests for convergence; Power series, Taylor and Maclaurin series; Taylor theorem, convergence of Taylor series, error estimates.
IV	Multivariable Calculus (Differentiation):	Limit, continuity and partial derivatives, directional derivatives, gradient, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers.
V	Multivariable Calculus (Integration)	Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Gradient, curl and divergence, Theorems of Green, Gauss and Stokes.

Suggested Books [Latest edition]:

1. Mathematics-I (Calculus & Linear Algebra), Khanna Book Publishing Co.
2. Reena Garg, Engineering Mathematics, Khanna Book Publishing Company, 2022.
3. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2021.
4. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
5. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
6. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
7. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
8. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Programming for Problem Solving

Credit: 4
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Introduction to Programming	Introduction to components of a computer system (disks,memory, processor, where a program is stored and executed, operating system, compilers etc.)Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart / Pseudocode with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.
II	Concept of Operator	Arithmetic expressions and precedence
III	Concept of Loop	Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.
IV	Concept of Array	Arrays, Arrays (1-D, 2-D), Character arrays and Strings
V	Concept of Sorting	Basic Algorithms, Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)
VI	Concept of Function	Function, Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference,
VII	Concept of Recursion	Recursion, Recursion as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.
VIII	Concept of Structure	Structures, Defining structures and Array of Structures
IX	Concept of Pointer	Pointers, Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)
X	Concept of File Handling	File handling (only if time is available, otherwise should be done as part of the lab).

Practical:

1. Familiarization with programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving if-then-else structures
4. Iterative problems e.g., sum of series
5. 1D Array manipulation
6. Matrix problems, String operations
7. Simple functions
8. Programming for solving Numerical methods problems
9. Recursive functions
10. Pointers and structures
11. File operations

Suggested Books [Latest edition]:

1. AICTE's Prescribed Textbook: Programming for Problem Solving, Khanna Book Publishing Co.
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill.
3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India.

Computer Organization and Architecture

Credit: 5
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Basics	Role of abstraction, basic functional units of a computer, Von-Neumann model of computation, A note on Moore's law, Notion of IPC, and performance. Data representation and basic operations.
II	Instruction Set Architecture (RISC-V)	CPU registers, instruction format and encoding, addressing modes, instruction set, instruction types, instruction decoding and execution, basic instruction cycle, Reduced Instruction Set Computer (RISC), Complex Instruction Set Computer (CISC), RISC-V instructions; X86 Instruction set.
III	The Processor	Revisiting clocking methodology, Amdahl's law, Building a data path and control, single cycle processor, multi-cycle processor, instruction pipelining, Notion of ILP, data and control hazards and their mitigations.
IV	Memory hierarchy	SRAM/DRAM, locality of reference, Caching: different indexing mechanisms, Trade-offs related to block size, associativity, and cache size, Processor-cache interactions for a read/write request, basic optimizations like write through/ write-back caches, Average memory access time, Cache replacement policies (LRU), Memory interleaving.
V	Storage and I/O	Introduction to magnetic disks (notion of tracks, sectors), flash memory. I/O mapped, and memory mapped I/O. I/O data transfer techniques: programmed I/O, Interrupt-driven I/O, and DMA.
VI	Superscalar processors and multicore systems	Limits of ILP, SMT processors, Introduction to multicore systems and cache coherence issues

Suggested Books [Latest edition]:

1. M. Morris Mano, Computer System & Architecture, Prentice Hall of India, 2002.
2. John L. Hennessy and David A Patterson, Computer Architecture-A quantitative approach, Morgan Kaufmann/ Elsevier, 4th Edition, 2007.
3. Hayes. J.P, Computer architecture and organization by McGraw-Hill Companies, 1998
4. Parallel Computer Architecture: A Hardware/Software Approach David Culler and J.P. Singh with Anoop Gupta, Morgan Kaufmann, 1998.

Universal Human Values: Understanding Harmony and Ethical Human Conduct

Credit: 3
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Introduction to Value Education	Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education), Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Practice Session PS2 Exploring Human Consciousness, Happiness and Prosperity – Current Scenario, Method to Fulfill the Basic Human Aspirations, Practice Session PS3 Exploring Natural Acceptance
II	Harmony in the Human Being	Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health
III	Harmony in the Family and Society	Harmony in the Family – the Basic Unit of Human Interaction and 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Other Feelings, Justice in Human-to-Human Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order
V	Implications of the Holistic Understanding – a Look at Professional Ethics	Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics, Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession

Suggested Books [Latest edition]:

1. The Textbook - A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93- 87034-47-1
2. The Teacher's Manual- Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, RR Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53
3. Professional Ethics and Human Values, Premvir Kapoor, ISBN: 978-93-86173-652, Khanna Book Publishing Company, New Delhi, 2022.
4. JeevanVidya: EkParichaya, A Nagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
5. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
6. The Story of Stuff (Book).
7. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
8. Small is Beautiful - E. F Schumacher.
9. Slow is Beautiful - Cecile Andrews
10. Economy of Permanence - J C Kumarappa

Design Thinking

Credit: 1
Semester: I
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	An Insight to Learning	Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting
II	Remembering Memory	Understanding the Memory process, Problems in retention, Memory enhancement techniques
III	Emotions: Experience & Expression	Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers
IV	Basics of Design Thinking	Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – Empathize, Define, Ideate, Prototype, Test
V	Being Ingenious & Fixing Problem	Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving
VI	Process of Product Design	Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, Assignment – Engineering Product Design
VII	Prototyping & Testing	What is Prototype? Why Prototype? Rapid Prototype Development process, Testing, Sample Example, Test Group Marketing
VIII	Celebrating the Difference	Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences
IX	Design Thinking & Customer Centricity	Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design
X	Feedback, Re-Design & Re-Create	Feedback loop, Focus on User Experience, Address "ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – "Solving Practical Engineering Problem through Innovative Product Design & Creative Solution".

Suggested Books [Latest edition]:
E Balaguruswamy (2022), Developing Thinking Skills (The way to Success), Khanna Book Publishing Company.

SEMESTER II

Physics

Credit: 5
Semester: II
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Introduction to Electromagnetic Theory	Electrostatics in vacuum, Electrostatics in a linear dielectric medium, Magneto statics, Magneto statics in a linear magnetic medium, Faraday's law, Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations, Electromagnetic waves
II	Introduction to Mechanics	Newtonian Mechanics and Coordinate Transformations, Conservative Forces and Central Force Motion, Non-Inertial Reference Frames and Rotational Dynamics, Oscillations and Damping, Planar Rigid Body Dynamics, Three-Dimensional Rigid Body Motion
III	Quantum Mechanics for Engineers	Wave nature of particles and the Schrodinger equation, Mathematical Preliminaries for quantum mechanics, Applying the Schrodinger equation, Introduction to molecular bonding, Introduction to solids,
IV	Oscillations, waves and optics	Simple harmonic motion, damped and forced simple harmonic oscillator, Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion, The propagation of light and geometric optics, Wave optics, Lasers,

Practical:
The following topics are to be covered:

1. Experiments on electromagnetic induction and electromagnetic braking;
2. LC circuit and LCR circuit;
3. Resonance phenomena in LCR circuits;
4. Magnetic field from Helmholtz coil;
5. Measurement of Lorentz force in a vacuum tube.
6. Coupled oscillators;
7. Experiments on an air-track;
8. Experiment on moment of inertia measurement,
9. Experiments with gyroscope;
10. Resonance phenomena in mechanical oscillators.
11. Frank-Hertz experiment; photoelectric effect experiment; recording hydrogen atom spectrum.
12. Diffraction and interference experiments (from ordinary light or laser pointers); measurement of speed of light on a table top using modulation; minimum deviation from a prism.

Suggested Books[Latest edition]:

1. Physics (Introduction to Electromagnetic Theory) with Lab Manual, Khanna Book Publishing Company.
2. Bhattacharya & Nag, Engineering Physics
3. David Griffiths, Introduction to Electrodynamics
4. Halliday and Resnick, Physics
5. W. Saslow, Electricity, magnetism and light
6. Malik, Singh, Engineering Physics, Tata McGraw Hill
7. Physics (Oscillations, Waves & Optics) with Lab Manual, Khanna Book Publishing.
8. Bhattacharya & Nag, Engineering Physics
9. Ian G. Main, Oscillations and waves in physics
10. H.J. Pain, The physics of vibrations and waves

Mathematics-II

Credit: 4
Semester: II
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Matrices	Linear Systems of Equations; Linear Independence; Rank of a Matrix; Determinant, Inverse of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Orthogonal transformation; Diagonalization of matrices; Cayley-Hamilton Theorem.
II	First order ordinary differential equations	Exact, linear and Bernoulli's equations. Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.
III	Ordinary differential equations of higher orders	Second order linear differential equations with variable coefficients: Euler-Cauchy equations, solution by variation of parameters; Power series solutions: Legendre's equations and Legendre polynomials, Frobenius method, Bessel's equation and Bessel's functions of the first kind and their properties.
IV	Complex Variable – Differentiation	Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.
V	Complex Variable – Integration	Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Suggested Readings [Latest edition]:

1. Mathematics-II (Calculus, Ordinary Differential Equations and Complex Variable), Khanna Book Publishing Co.
2. Reena Garg, Engineering Mathematics, Khanna Book Publishing Company, 2022.
3. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2021.
4. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2006.
5. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
6. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
7. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
8. S. L. Ross, Differential Equations, 3rd Edition, Wiley India, 1984.

9. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
10. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.

Mathematical Concepts for Artificial Intelligence

Credit: 4
Semester: II
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Equations, Functions and Graphs	Introduction to linear equations, Intercepts and slopes, System of equations, Exponentials, radicals and logarithms, Polynomials, Polynomial operations, Factorizations, Introduction to quadratic equations, Functions
II	Derivatives and Optimizations	Rate of change, Introduction to limits, Continuity, finding limits, Differentiability, Derivative rules and operations, using derivatives to analyse functions, Second order derivatives, Optimization functions, Multivariate differentiation
III	Vectors and Matrices	Introduction to vectors, Vector addition, vector multiplication, Introduction to matrices, matric multiplication, properties of matrices, types of matrices, Matrix division, solving system of equations with matrices, Matrix transformations, Eigen values and eigen vectors, rank of matrix
IV	Probability	Basic rules and axioms events, sample space, dependent and independent events, conditional probability, Random variables- continuous and discrete, expectation, variance, distributions- joint and conditional, Bayes' Theorem, Popular distributions- binomial, Bernoulli, poisson, exponential, Gaussian
V	Statistics	Fundamentals of Data: Collection, Summarization, and Visualization; Sampling and Sampling Distributions, Central Limit Theorem; Methods of Estimation, Unbiased estimators; Confidence Interval Estimation: Z-interval, t-interval; Hypothesis Testing, Types of Errors, Rejection Region Approach and p-value Approach.

Suggested Readings [Latest edition]:

1. Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press., 2020
2. Advanced Engineering Mathematics, Reena Garg, Khanna Book Publishing Co., Delhi.
3. Machine Learning, Rajiv Chopra, Khanna Book Publishing Co., Delhi.
4. Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, Stephen Boyd, Lieven Vandenberghe, Cambridge University Press., 2018
5. Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education, 2012
6. Advanced Engineering Mathematics, Wylie and Barrett, McGraw Hill, 1995

Data Structure and Algorithms

Credit: 5
Semester: II
Nature of the Course: Elective Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Introduction and basic terminology	Notion of data structures and algorithms, $l$og n, n, 2^n understanding growth of these functions, and applications (binary search and extensions to similar problems) Worst-case, average case time/space complexity and their relative merits. Asymptotic Notation: $O(\ ), \Omega(\ )$
II	Abstract Data-types, Arrays, Linked Lists, Stacks, Queues Dictionary ADT, Trees, Binary Trees	Abstract data-type (ADTs): arrays and linked list ADTs. Stacks, Queues: ADTs and implementations using arrays, linked lists. Doubly linked lists: ADT and implementation Dictionary ADT: implementation using array, linked lists, binary search. Tree ADT and Examples Implementation of trees and basic traversal Algorithms Binary trees and in order traversal
III	Priority Queues and Heaps	Priority Queue ADT, Definition of heaps, Implementation of Priority Queues using heaps and running time analysis Implementation of heaps using arrays. Heap-sort
IV	Binary Search Trees, AVL Trees, 2-4 trees	Binary Search Trees: definition and some basic algorithms. Implementation of Dictionary ADTs using Binary Search trees and running time analysis, AVL trees: height balance condition, rotations, and implementation of dictionary ADT 2-4 Trees: Multi-way search trees, implementation of dictionary ADT, Informal discussion of extension to B-trees.
V	Hash tables, tries	Map ADT, Hash Tables and implementation of Map using Hash Tables Design of hash functions Collision resolution schemes: chaining, open addressing schemes like linear probing, quadratic probing, double hashing. Applications of Hashing: finding duplicates, set intersection, etc. Tries: implementation of Map ADT using tries. Compressed tries and suffix tries.
VI	Sorting, Selection	Bubble sort, insertion sort, selection sort, Merge sort and divide and conquer paradigm Quick sort: average and worst case analysis, randomized quicksort (intuitive explanation), Selection based on partitioning ideas used in Quick Sort.
VII	Graphs, representations and traversal algorithms, applications of BFS, DFS	Graph ADTs and applications Adjacency list and adjacency matrix representations and relative merits Basic graph, definitions: paths, cycles, trees, spanning trees, connected components, Euler's formula. Depth First Search Traversal algorithm for directed graphs: classification of edges into forward, back and cross edges. Applications to cycle finding, topological sort in directed acyclic graphs, finding connected components. Running time analysis. Breadth first search algorithm: implementation using queues, shortest path tree property. Running time analysis

Suggested Books [Latest edition]:

1. “Expert Data Structures with C” by R.B. Patel, Khanna Book Publishing Company, New Delhi, 4th Edition.
2. “Data Structures and Algorithms in Java”, by Michael T. Goodrich and Roberto Tamassia, John Wiley & Sons; 3rd Edition.
3. “Data Structures and Algorithms in Python”, by Michael T. Goodrich and Robert, Tamassia, Wiley, 1st Edition.
4. “Taming Python by Programming”, Jeeva Jose, Khanna Book Publishing Company.
5. “Fundamentals of Data Structures”, Sartaj Saini, University Press.

Discrete Mathematics

Credit: 3
Semester: II
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Mathematical Reasoning	Mathematical reasoning, Propositions, Negation, disjunction and conjunction, Implication and Equivalence, Truth tables, Predicates, Quantifiers, Natural deduction, Rules of Inference, Methods of proofs, Resolution principle, Application to PROLOG.
II	Set Theory	Paradoxes in set theory, Inductive definition of sets and proof by induction, Peano postulates, Relations, Properties of relations, Equivalence Relations and partitions, Partial orderings, Posets, Linear and well-ordered sets.
III	Combinatorics and Functions	Elementary Combinatorics, counting techniques, Recurrence relation, Generating functions, Functions; mappings, Injection and Surjections, Composition of functions, Inverse functions, Special functions, Pigeonhole principle, Recursive function theory.
IV	Graph Theory	Elements of graph theory, Euler graph, Hamiltonian path, trees, Tree traversals, Spanning trees, Representation of relations by graphs.
V	Groups, Rings, Fields, Discrete Probability	Definition and elementary properties of groups, Semigroups, Monoids, Rings, Fields, Vector spaces and lattices, Introduction, Discrete random variables, Applications to Binary Search Tree.

Suggested Books [Latest edition]:

1. K. H. Rosen, Discrete Mathematics and applications, 6th Edition, Tata McGraw Hill 2007.
2. S.B. Singh, Discrete Structures/ 3rd Edition, Khanna Book Publishing, 2019.
3. S.B. Singh, Combinatorics and Graph Theory/ 3rd Edition, Khanna Book Publishing, 2018.
4. C. L. Liu, Elements of Discrete Mathematics, 2nd Edn., Tata McGraw-Hill 2000.
5. J .L. Mott, A. Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists and Mathematicians, Second edition, Prentice Hall of India 1986.
6. W. K. Grassmann and J. P. Trembnlay, Logic and Discrete Mathematics, A Computer Science Perspective, Prentice Hall Inc 1996

Communicative English

Credit: 3
Semester: II
Nature of the Course: Core Course

Course Content:

Module No.	Module Name	Chapter Topic
I	Vocabulary Building	The concept of Word Formation, Root words from foreign languages and their use in English, Acquaintance with prefixes and suffixes from foreign languages in English to form Derivatives, Synonyms, antonyms, and standard abbreviations.
II	Basic Writing Skills	Sentence Structures, Use of phrases and clauses in sentences, Importance of proper punctuation, Creating coherence, Organizing principles of paragraphs in documents, Techniques for writing precisely
III	Identifying Common Errors in Writing	Subject-verb agreement, Noun-pronoun agreement, Misplaced modifiers, Articles, Prepositions, Redundancies, Clichés
IV	Nature and Style of sensible Writing	Describing, Defining, Classifying, Providing examples or evidence, Writing introduction and conclusion
V	Writing Practices	Comprehension, Précis Writing, Essay Writing

Practical:
The following topics are to be covered:

1. Listening Comprehension
2. Pronunciation, Intonation, Stress and Rhythm
3. Common Everyday Situations: Conversations and Dialogues
4. Communication at Workplace
5. Interviews
6. Formal Presentations

Suggested Books [Latest edition]:

1. English (with Lab Manual), Khanna Book Publishing Co.
2. Effective Communication Skills. Kul Bhushan Kumar, Khanna Book Publishing, 2022.
3. Practical English Usage. Michael Swan. OUP. 1995.
4. Remedial English Grammar. F.T. Wood. Macmillan.2007
5. On Writing Well. William Zinsser. Harper Resource Book. 2001
6. Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
7. Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
8. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press.