

Course Curriculum- Software Engineering Department

Introduction to Computing

Course Contents: Introduction to computer systems (main categories, its hardware and software and their interaction with each other), Number Systems, Binary number system, Boolean logic, History of computer systems, basic machine organization, Von Neumann Architecture, Algorithm definition, design, and implementation, flow charts, Programming paradigms and languages, Overview of Software Engineering and Information Technology, Operating system, Compiler, Computer networks and internet, Computer graphics, Artificial Intelligence.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) – PLO
Describe the main components of computer systems, their interaction with each other and internal working.	C - 2	1
Analyze algorithms using pseudo code or flow chart to demonstrate problem-solving skills.	C - 4	2

Discrete Structure

Course Contents: Introduction to propositional and predicate logic, rules of inference, proof by induction, proof by contraposition, proof by contradiction, proof by implication, set theory, relations, equivalence relations and partitions, partial orderings, recurrence relations, functions, mappings, function composition, inverse functions, recursive functions, Number Theory, sequences, series, counting, inclusion and exclusion principle, pigeonhole principle, permutations and combinations, elements of graph theory, planar graphs, graph coloring, Euler

graph, Hamiltonian path, rooted trees, traversals.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) -PLO
Identify the knowledge of elementary discrete probability concepts and solve problems which involve discrete data structures such as sets, relations, functions etc.	C - 1	1
To Discuss the complex problems and find their solution using mathematical developed skills	C - 2	2
Apply the mathematical concepts learned to various areas of computer science	C - 3	5

Applied Physics

Course Contents: Electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charge isolated conductor, Electric potential energy, Electric potentials, Calculating the potential from the field and related problem Potential due to point and continuous charge distribution, Potential due to dipole, equi-potential surfaces, Calculating the field from the potential, Electric current, Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot- Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroids, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf, Induced electric field, Induced electric fields, The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
State the fundamental of physics to understand Electrostatics, Electronics and Magneto statics	C - 1	1
Discuss the problem for electromagnetic field in the region surrounded by different static and moving charge configuration.	C - 2	1

Functional English

Course Contents: Making introductions , Making effective self and peer introductions , Taking useful introductory notes, Expressing requests and enquiries Forming appropriate requests and enquiries , Responding to enquiries, Requests versus commands, Practicing practical classroom English , Using different classroom , language routines and functions for effective classroom management, Developing effective classroom language by following provided examples , Demonstrating and practicing practical classroom language routines, Greetings, Gratitude, Invitations, Writing styles , Changing narration: Converting a dialogue into a report , Converting a story into a news report , Converting a graph or picture into a short report or story, Writing mechanics, Punctuation and structure , Sentences, sentence fragments, and run-on sentences, Subject-predicate and pronoun-reference agreement.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
State knowledge and improve the skills of communication in their respective domain.	C - 1	09
Apply the practice for improving the students' vocabulary and grammar errors	C - 3	10

To enable student to contribute towards drafting of text for technical and research documents	A-2	10
Be aware of effective communication with diverse audiences in a variety of ways for different purposes	A-1	12

Calculus & Analytical Geometry

Course Contents: Complex Numbers, DeMoivre’s Theorem and its Applications, Simple Cartesian Curves, Functions and Graphs, Symmetrical Properties, Curve Tracing, Limit and Continuity, Differentiation and Functions, Derivative as Slope of Tangent to Curve and Rate of Change, Application to Tangent and Normal, Linearization, Maxima/Minima and Point of Inflexion, Taylor and Maclaurin Expansions and their convergence, Integral as Anti-derivative, Indefinite Integration of Simple Functions, Methods of Integration: Integration by substitution, by Parts, and by Partial Fractions, Definite Integral as Limit of a Sum, Application to Area, Arc Length, Volume and Surface of Revolution.

Course Learning Outcome(s) - CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
State knowledge related to basic concepts of calculus (limits, functions etc.)	C - 1	1
Apply concepts for analysis and solution engineering related problems	C - 3	2

Introduction to Software Engineering

Course Contents: Nature of Software, Overview of Software Engineering, Professional software development, Software engineering practice, Software process structure, Software process models, Agile software Development, Agile process models, Agile development techniques, Requirements engineering process, Functional and non-functional requirements, Context models, Interaction models, Structural models, behavioral models, model driven engineering, Architectural design, Design and implementation, UML diagrams, Design patterns, Software testing and quality assurance, Software evolution, Project management and project planning, configuration management, Software Process improvement.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Define the basic concepts of Software Engineering, its generic processes, and activities.	C - 1	1
Apply software engineering concepts to model a medium size software system/given problem.	C - 3	1

Digital Logic & Design

Course Contents: Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn McCluskey method), Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA); Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.

Course Learning Outcome(s) - CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Describe different number systems, binary codes, logic gates, Boolean algebra and circuit minimization.	C - 2	1
Analyze small-scale combinational and sequential circuits	C - 4	2
Design combinational and sequential circuits using various minimization techniques	C - 5	3
Apply techniques related to the design and analysis of digital electronic circuits.	C-3	4

Programming Fundamental

Course Contents: Introduction to problem solving, a brief review of Von-Neumann architecture, Introduction to programming, role of compiler and linker, introduction to algorithms, basic data types and variables, input/output constructs,

arithmetic, comparison and logical operators, conditional statements and execution flow for conditional statements, repetitive statements and execution flow for repetitive statements, lists and their memory organization, multi-dimensional lists. Standard template library.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Define the basic concept and knowledge of programming	C - 1	1
Analyze the specialized knowledge of programming and comprehend their structures.	C - 4	4
Apply new movement patterns and suitable techniques to create basic level programs for beginner's	C - 3	3

Linear Algebra and Differential Equations

Course Contents: Algebra of linear transformations and matrices. determinants, rank, systems of equations, vector spaces, orthogonal transformations, linear dependence, linear Independence and bases, eigenvalues and eigenvectors, characteristic equations, Inner product space and quadratic forms. Ordinary Differential Equations of the First Order: Geometrical Considerations, Isoclines, Separable Equations, Equations Reducible to Separable Form, Exact Differential Equations, Integrating Factors, Linear First-Order Differential Equations, Variation of Parameters.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Define the concepts of matrices and matrix algebra, systems of linear equations and their solutions, vector spaces, subspaces, bases, Linear transformations, eigen values, eigen vectors.	C - 1	1
Solve the Solutions of Initial value problems (IVP's) and Higher order differential Equations	C - 3	1

Combine the knowledge of linear systems and ordinary differentialequations concepts to model physical systems	C - 5	5
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Communication Skills

Course Contents: Principles of writing good English, understanding the composition process: writing clearly; words, sentence and paragraphs; Comprehension and expression; Use of grammar and punctuation. Process of writing, observing, audience collecting, composing, drafting and revising, persuasive writing, reading skills, listening skills and comprehension, skills for taking notes in class, skills for exams; Business communications; planning messages, writing concise but with impact. Letter formats, mechanics of business, letter writing, letters, memo and applications, summaries, proposals, writing resumes, styles and formats, oral communications, verbal and non-verbal communication, conducting meetings, small group communication, taking minutes. Presentation skills; presentation strategies, defining the objective, scope and audience of the presentation, material gathering material organization strategies, time management, opening and concluding, use of audio-visual aids, delivery and presentation.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Understanding the basics of effective communication skills.	C - 1	1
Apply the communication abilities for developing better interpersonal skills.	C - 3	10
Express communication as a dynamic interactive process that involvesthe effective transmission of facts, ideas, thoughts, feelings and values	A - 3	8
Adapt communication skills to use English in professional life	A-4	9
Pay attention to communication errors usually made by the learners ofEnglish	A1	12

Software Requirement Engineering

Course Contents: Introduction to Requirements Engineering, Software Re-

quirements, classification of requirements, Requirements process, Levels/layers of requirements, Requirement characteristics, Analyzing quality requirements, Software requirements in the context of systems engineering, Requirement evolution, requirement traceability, requirement prioritization, trade-off analysis, risk analysis and impact analysis, Requirement management, interaction between requirement and architecture, Requirement elicitation, elicitation sources and techniques, Requirement specification and documentation, specification sources and techniques, Requirements validation and techniques, Management of Requirements, Introduction to Management, Requirements Management Problems , Managing Requirements in an Acquisition Organization, Supplier Organizations, Product Organizations, Requirements engineering for agile methods.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Discuss the Software Requirements Engineering Process and different types of software requirement	C - 2	1
Apply the core principles of Requirement Engineering	C - 3	2
Construct Software Requirement Specification document by analyzing the customer needs	C - 5	4
Use standard communication techniques to elicit requirements	C-3	10

Data Structure and Algorithm

Course Contents: Abstract data types, complexity analysis, Big Oh notation, Arrays (static and dynamic) Stacks(linked lists and array implementations), Recursion and analyzing recursive algorithms, divide and conquer algorithms, Sorting algorithms (selection, insertion, merge, quick, bubble, heap, shell, radix, bucket), queue, dequeuer, priority queues (linked and array implementations of queues), linked list & its various types, sorted linked list, searching an unsorted array, binary search for sorted arrays, hashing and indexing, open addressing and chaining, trees and tree traversals, binary search trees, heaps, M-way trees, balanced trees, graphs, breadth- first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Describe the fundamentals of data structure and algorithms designing	C - 2	1
Develop data structures with their operations in programming language	C - 5	3
Solve computational problems by applying the appropriate algorithm on structured data	C - 3	2
Propose data structure according to their typical usage, strengths and weakness for designing optimised computer based systems	C-5	4

Technical Report Writing

Course Contents: Overview of technical reporting, use of library and information gathering, administering questionnaires, reviewing the gathered information; Technical exposition; topical arrangement, exemplification, definition, classification and division, casual analysis, effective exposition, technical narration, description and argumentation, persuasive strategy, Organizing information and generation solution: brainstorming, organizing material, construction of the formal outline, outlining conventions, electronic communication, generation solutions. Polishing style: paragraphs, listening sentence structure, clarity, length and order, pomposity, empty words, pompous vocabulary, document design: document structure, preamble, summaries, abstracts, table of contents, footnotes, glossaries, cross-referencing, plagiarism, citation and bibliography, glossaries, index, appendices, typesetting systems, creating the professional report; elements, mechanical elements and graphical elements. Reports: Proposals, progress reports, Leaflets, brochures, handbooks, magazines articles, research papers, feasibility reports, project reports, technical research reports, manuals and documentation, thesis. Electronic documents, Linear verses hierarchical structure documents.

Course Learning Outcome(s) - CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
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Explain technical writing memos, proposals, covering letter, fliers, brochures, newsletters, business letter skills	C - 2	10
Demonstrate in group Presentations using different techniques	C - 3	9
Adopt ethical measures to produce the technical report and internship report for the better presentation of work	A-3	8
Adopt all the technicalities of formal writing to be used in professional lives	A-3	12

Numerical & Symbolic Computing

Course Contents: Mathematical preliminaries and error analysis, round-off errors and computer arithmetic, Calculate Divided Differences. Use Divided-difference Table. Find Newton's Interpolation Polynomial. Calculate Interpolation with Equally Spaced Data. Find the Difference Table. Calculate, Newton's Forward & Backward Difference Formulae. Use Gauss Formulae. Use Stirling's Interpolation Formula. Use Bessel's Interpolation Formula. Use Everett's Interpolation Formula. Solve Nonlinear Equations. Solve Equations by Bisection Method. Solve Equations by Regula Falsi Method. Solve Equations by Secant Method. Solve Equations by Newton- Raphson Method. Find Fixed Point Iteration. Solve Equations by Jacobi Iterative Methods. Solve Equations by Gauss Seidel Method Calculate Numerical Differentiation. Find Numerical Differentiation Formulae Based on Equally Spaced Data. Find Numerical Differentiation Based on Newton's Forward Differences. Find Numerical Differentiation Based on Newton's Backward Differences. Find Numerical Differentiation Based on Stirling's Formula. Find Numerical Differentiation Based on Bessel's Formula. Find Numerical Differentiation Based on Lagrange's Formula. Calculate Error Analysis of Differentiation Formulae. Solve Richardson Extrapolation. Calculate Numerical Integration. Use Trapezoidal Rule with Error Term. Use Simpson's 1/3 Rule with Error Term. Use Simpson's 3/8 Rule with Error Term. Use Composite Numerical Integration. Use Composite Trapezoidal Rule. Use Composite Simpson's Rule. Find Richardson's Extrapolation

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
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Apply numerical analysis methods and using software for simpler to complex problems of applied engineering and defined the practical examples.	C - 3	1
Analyse analytical methods in solving complex engineering as well as daily life problems.	C - 4	4

Islamic Study

Course Contents: Basic Themes of Quran, Introduction to Sciences of Hadith, Introduction to Islamic Jurisprudence, Primary & Secondary Sources of Islamic Law, Makken & Madnian life of the Prophet, Islamic Economic System, Political theories, Social System of Islam.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the concept of faith and basic pillars of Islam, its relation with human life and impact on society	C - 2	6
Exemplify the Holy Prophet (PBUH) life style to learn Islamic ethics, culture and personal grooming.	A - 5	8
Outline fundamental problems in the Islamic law framework from the perspectives of economic, and social cultures.	C - 4	6

Pak-Studies

Course Contents: Historical background of Pakistan: Muslim society in Indo-Pakistan, the movement led by the societies, the downfall of Islamic society, the establishment of British Raj- Causes and consequences. Political evolution of Muslims in the twentieth century: Sir Syed Ahmed Khan; Muslim League; Nehru; Allama Iqbal: Independence Movement; Lahore Resolution; Pakistan culture and society, Constitutional and Administrative issues, Pakistan and its geo-political dimension, Pakistan and International Affairs, Pakistan and the challenges ahead.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Illustrate the concept behind Pakistan's formation and the process that happened to create it.	C - 3	10
Communicate concise overview of post-partition political and legal developments.	A - 2	12
Examine Pakistan's emerging environmental and social problems, as well as their sources and strategies to solve them.	C - 4	7

Operating Systems

Course Contents: Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multi-threading models, threading issues, process scheduling algorithms, thread scheduling, multiple-processor scheduling, synchronization, critical section, synchronization hardware, synchronization problems, deadlocks, detecting and recovering from deadlocks, memory management, swapping, contiguous memory allocation, segmentation & paging, virtual memory management, demand paging, thrashing, memory-mapped files, file systems, file concept, directory and disk structure, directory implementation, free space management, disk structure and scheduling, swap space management, system protection, virtual machines, operating system security.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the basic OS principles, processes, threads, IPC, files etc	C - 2	1
Analyze Operating Systems core functions such as process and memory management.	C - 4	2
Prepare the solution of real world problems by analysis of OS tools and techniques	C - 3	4

Object Oriented Programming

Course Contents: Introduction to object oriented design, history and advantages of object oriented design, introduction to object oriented programming concepts, classes, objects, data encapsulation, constructors, destructors, access modifiers, const vs non-const functions, static data members & functions, function overloading, operator overloading, identification of classes and their relationships, composition, aggregation, inheritance, multiple inheritance, polymorphism, abstract classes and interfaces, generic programming concepts, function & class templates, standard template library, object streams, data and object serialization using object streams, exception handling.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Describe the basic concept and knowledge of object oriented programming	C - 2	1
Apply the major object-oriented concepts and implement object oriented programs in C++, encapsulation, inheritance and polymorphism	C - 3	3
Analyse object oriented programming principles to implement small and medium scale C++ programs with simple graphical user interface	C-4	4

Software Architecture Design

Course Contents: Software Design Concepts, Design principles, Object-Oriented Design with UML, System design and software architecture, Object design, Mapping design to code, User interface design, Persistent layer design, Web applications design, State machine diagrams and modeling, Agile software engineering, Design Patterns, Exploring inheritance, Interactive systems with MVC architecture, Software reuse. Architectural design issues, , Software Architecture, Architectural Structures & Styles-, Architectural Patterns, Architectural & Design Qualities, Quality Tactics, Architecture documentation, Architectural Evaluation, Model driven development.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Explain major activities and main role of design involved in object oriented software development process	C - 2	1
Design a solution to a given problem using one or more design models and implement in a programming language.	C - 5	3
Use existing solutions i.e architectural styles and software design patterns of a particular software system design problem for evaluation	C-4	4

Introduction to Database System

Course Contents: Basic database concepts, Database approach vs file based system, database architecture, three level schema architecture, data independence, relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints, relational algebra, selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Structured Query Language (SQL), Joins and sub-queries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, NoSQL systems.

Course Learning Outcome(s) - CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Defining basic concepts database management systems and models	C - 1	1
Identify the normalizations functional dependencies and resolve them using	C - 1	2

Use SQL language to perform database manipulation operations	C - 3	3
Compare different stages of database development using various datamodels	C-4	4

Principles of Management Course Contents:

Introduction to Project Management, the Project Management and Information Technology Context, the Project Management Process Groups, Project Integration Management, Project Scope Management. Project Time Management, Project Cost Management, Project Quality Management, Project Human Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management, Project Management Tools.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Adopt critical thinking and focus on managerial problems in an articulate way to figure out the solution	A -3	7
Follow the management process and know the contemporary management practice in different applications	A - 2	11
Classify various management theories and apply effectively	A-4	9
Demonstrate the ability to recognise the need and adaptation to change	C-3	12
Apply foundation knowledge of management principles and functions	C-3	10

Formal Methods in Software Engineering

Course Contents: Introduction to the use of mathematical models for specification and validation, Finite state machine models, models of concurrent systems, verification of models, and limitations. Analyzing well- formedness (e.g. completeness, consistency, robustness, etc.), Analyzing correctness (e.g. static analysis, simulation, model checking, etc.), Formal analysis, An introduction to VDM-SL, Sets, Sequences, Composite objects, Maps, VDM-SL, Comparative Formal Methods, Proofs, Introduction to Z.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the fundamental concepts of formal methods.	C - 2	1
Carry out formal specifications and verification by applying formal method concepts.	C - 3	4
Interpret and apply the formal languages of the formalisms for modeling distributed systems	C-6	4

Software Verification & Validation

Course Contents: Introduction to the course and course policies, Critical analysis of software requirements and analysis of proposed solutions, Overview of software testing, test levels, scope and test types, Testing lifecycle and methodologies , Non-functional testing, Testing artifacts and deliverables , Test management metrics and reporting, management, Tools and techniques to support the testing process, Formal methods for software verification (including higher order logic, natural deduction, lambda calculus, term rewriting, data types and recursive functions, induction principles, calculation reasoning, mathematical proofs, decision procedures for a variety of logical domains, and proofs about programs.)

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Define software verification and validation concept, principles and fundamentals	C - 1	1
Demonstrate the software development process, The testing process, concepts on which state-of-the-art software testing techniques are based	C - 3	4
Analyse all testing artefacts and produce deliverables	C-4	2

Design test cases to validate and verify software	C-5	3
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Object Oriented Software Engineering

Course Contents: Introduction to Software Engineering, Modelling with UML, Project Organization and Communication, Requirements Elicitation, Analyses, System Design: Decomposing the System, System Design: Addressing Design Goals, Object Design: Reusing Pattern Solutions, Object Design: Specifying Interfaces, Mapping Models to Code, Testing, Rationale Management, Configuration Management, Project Management, Software Life Cycle, Methodologies: Putting It All Together.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Identify various O-O concepts along with their applicability contexts.	C - 1	1
Solve the problem using objected oriented software engineering principles	C - 3	2
Analyse object oriented software engineering principles to implement small and medium scale software.	C-4	4

Software Engineering Economics

Course Contents: Programming aspects, economic aspects, human relations aspects, software trends: cost, social impact, the plurality of SE Means, The GOALS Approach to Software Engineering, The Software Work Breakdown Structure (WBS), Software Maintenance, introduction to COCOMO, definitions and assumptions, development effort and schedule, phase distribution, The Rayleigh Distribution, interpolation, basic software maintenance effort estimation. Performance Models, Optimal Performance, Sensitivity Analysis, Cost- Effectiveness Models. Cost Drivers: Project Attributes–Modern Programming Practices, Use of Software Tools, Schedule Constraint.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Describe and understand the importance of economics in software engineering	C - 2	1
Apply different tools for economic analysis	C - 3	5

Probability & Statistics

Course Contents: Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S^2 , t-Distribution, F-Quantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Define the basic concept of probability and statistics	C - 1	1
Apply probability concepts to solve engineering problems	C - 3	4

Web Engineering

Course Contents: Web programming languages (e.g., HTML5, CSS 3, Java Script, PHP/JSP/ASP.Net), Design principles of Web based applications, Web platform constraints, Software as a Service (SaaS), Web standards, Responsive Web Design, Web Applications, Browser/Server Communication, Storage Tier, Cookies and Sessions, Input Validation, Full stack state management, Web App Security - Browser Isolation, Network Attacks, Session Attacks, Large scale applications, Performance of Web Applications, Data Centers, Web Testing and Web Maintenance.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Define the concepts, principles and methods of web engineering	C - 1	1
Design and develop web applications using client side/server-side programming languages.	C - 5	3
Analyse the impact of web standards on software development	C - 4	4

Digital Image Processing

Course Contents: The human visual system, electromagnetic system, working and components inside digital camera, pixels, image representation, sampling, quantization, mathematics of image formation, convolution, point-based image processing, Fourier theory, image filtering in spatial and frequency domain, morphological operations, color models, Image compression, multispectral images, feature detection, image segmentation, etc.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Describe the fundamental knowledge of image and use their mathematical interpretation.	C - 2	1

Design various transformation functions for image enhancement for binary, grayscale and colour images.	C - 5	2
Evaluate algorithms for real-time problem-solving using tools like MATLAB and/or Python	C - 6	3

Compare various image processing algorithms	C-4	4
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Mobile Application and Development

Course Contents: Mobiles Application Development Platform; Android OS: Architecture, Framework and Application Development; Android Studio; Fragments; Lists; Recycler View; Calling Built-in Applications using Intents; Displaying Notifications; Components of a Screen; Adapting to Display Orientation; Managing Changes to Screen Orientation; Utilizing the Action Bar; Creating the User Interface; Listening for UI Notifications; Views; User Preferences; Persisting Data; Sharing Data; Sending SMS Messages; Displaying Maps; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages.

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
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Discuss different architectures & framework for Mobile Application development.	C - 2	1
Develop/Create mobile applications using current software development environments.	C - 5	3

Compare the different performance tradeoffs in mobile application development.	C - 4	5
Describe the mobile application development fundamentals and flow on multiple devices and publishing it online.	C-2	6
Adopt basic and advance concepts for generating sustainable solutions	A-4	7
Use resources to develop mobile application individually or team based	A-3	9
Formulate project planning activities that accurately forecast project cost, timeline and quality	A-4	11

Advance Database systems

Course Contents: Introduction to advance data models such as object relational, object oriented. File organizations concepts, Transactional processing and Concurrency control techniques, Recovery techniques, Query processing and optimization, Database Programming (PL/SQL, T-SQL or similar technology), Integrity and security, Database Administration (Role management, managing database access, views), Physical database design and tuning, Distributed database systems, Emerging research trends in database systems, MONGO DB, NO SQL (or similar technologies).

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Compare advance data models, technologies and approaches for building distributed database systems	C - 4	2
Design the models and approaches in order to become enabled to select and apply appropriate methods for a particular case	C - 5	3
To assess a database solution for a given scenario/ challenging problem in the domain of distributed database systems.	C - 6	4

Artificial intelligence

Course Contents: Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, First order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint Satisfaction Problems; Adversarial Search (Min-max algorithm, Alphabeta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning); Uncertainty handling (Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems)

Course Learning Outcome(s) - CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Discuss fundamentals of AI, different searching algorithms in AI like heuristic informed/uninformed search and knowledge based systems.	C - 2	1
Ability to apply AI techniques with machine learning to solve dynamic problems	C - 3	3
Analyse various AI models	C-4	4

Computer Communication & Networks

Course Contents: Introduction and protocols architecture, basic concepts of networking, network topologies, layered architecture, physical layer functionality, data link layer functionality, multiple access techniques, circuit switching and packet switching, LAN technologies, wireless networks, MAC addressing, networking devices, network layer protocols, IPv4 and IPv6, IP addressing, sub netting, CIDR, routing protocols, transport layer protocols, ports and sockets, connection establishment, flow and congestion control, application layer protocols, latest trends in computer networks.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
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Describe the basics of computer networks	C - 2	1
Compare the functionality and services of network layers	C - 4	2
Analyze the different algorithms and performance of protocols	C - 4	4

Software Testing

Course Content: Testing techniques. Black Box testing, White Box and Grey Box testing techniques. Quality Assurance planning and execution. Automated testing topics include constructing a framework, scripting techniques, generating a test data, generating test architecture, pre/post-processing, test maintenance, and job specific metrics. Current research topics in Software Testing and Quality Assurance.

COURSE LEARNING OUTCOME (CLO)	Blooms Taxonomy	PROGRAM LEARNING OUTCOME (PLO)
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State the principal approaches to software testing, together with their associated techniques.	C-1	1
Compare the distinction between the functional and structural based testing techniques.	C-4	4
Illustrate the Plan, design, implementation, documentation and execution of testing a software component or a system that implements a given softwarespecification.	C-3	1
Apply test automation techniques and testing tools in support of test execution and documentation.	C-5	3

Artificial Neural Networks (Elective General)*

Course Content: Introduction to the course and motivation, Machine learning introduction, advantages and applications, Machine learning basics (supervised, unsupervised, reinforcement learning), Training data, Training objectives, over-fitting, under-fitting problem, Classification and Regression problem, Introduction to neural networks, What are artificial neural networks?, Multi-layered feed-forward network I, Multi-layered feed-forward network II, Back propagation Neural Network, Gradient descent in neural networks I, Gradient descent in neural networks II, Implementing the neural network in Python, Application of Neural Networks in Telecommunication, Application of Neural Networks in Bioinformatics

COURSE LEARNING OUTCOME	Blooms Taxonomy	PROGRAM LEARNING OUTCOME (PLO)
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Explain the basics of artificial neural networks	C-2	1
Apply supervised and unsupervised Learning in machine learning using neural networks	C-3	3
Design and implementation of small problems	C-5	2
Outline the application of artificial neural networks	C-4	6
Explain how ANNs can be trained for sustainable solutions	C-2	7

Software Project Management

Course Content: Software Crisis and Software Engineering, Classic Mistakes, Overview of Project Management, PMI Process Groups, Software project Phases, Project charter, Statement of Work (SOW), Planning Phase: Development lifecycle models, matching lifecycles to projects, Project plans, Work Break-down Structures (WBS), Estimation of effort and cost (Expert Judgment, FP and Use Case point methods), Scheduling: Project network diagram fundamentals, CPM, PERT, Gantt charts, Critical chain scheduling, Using MS-Project, Assigning Resources, Resource leveling, Team models, Managing conflict and motivating, Project Monitoring and Control: Status reporting, Project metrics, EVM, Communications Techniques, Risk management and Change control Project Recovery, Documentation, Cutover/Migration, Post Project Reviews, Closing.

COURSE LEARNING OUTCOME (CLO)	Bloom's Taxonomy Level	PROGRAM LEARNING OUTCOME (PLO)
State the concepts of project management in the context of software development management process and MS Project as a modeling tool.	C-2	1
Analyse various techniques for planning and managing a software project, for the given problem.	C-4	4
Develop Software project management artefacts i.e SOW, SRS, and Project Planning documents to manage the project based on client needs.	C-5	11
Be aware of the role of professional ethics in successful software development	A-1	8
Illustrate an appropriate project management approach through an evaluation of the business context and scope of the project	C-3	11
Apply the knowledge of software project management practices on real time case studies	C-3	12

Human Resource Management:

Course Content: Need for Human Resources Management. Matching HR Needs and People. Developing People. Compensation and Recognition. Recruitment and Selection. Developing a Healthy Work Environment and Effective Employee Relations.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) -PLO
State the theoretical Knowledge and current Practices of Human Resource Management	C-1	11
Apply the knowledge of human Situations/Case studies/Scenarios. resource management in different	C-3	12
Asses the Practices of Human Resource Management in modern workplaces, in a group.	C-6	9
Describe competence in development and problem solving in areas of HR management	C-2	11
Identify and appreciate the significance of the ethical issues in HR	C-1	8
Formulate innovative and sustainable solutions to problems in the field of HR.	A-4	7
Demonstrate the competence in communicating and exchanging ideas in a group context.	P-4	10
Evaluate HR related social, cultural, ethical and environmental responsibilities and issues in a group context	C-6	6

Human Computer Interaction

Course Contents: Contexts for HCI, Psychology of usable things, Processes for User-Centered Design, Metrics and Measures for Evaluation, Usability heuristics and principles of Usability testing, Physical capabilities, Cognitive and social models for interaction design, Principles of good interaction design, Accessibility, Principles of GUI, Visual design elements, Data gathering, Task analysis, Prototyping, Help and user documentation, Internationalization, Usability inspection methods, Usability testing methods, New Interaction Technologies, Usability in practice, Visual Design and Typography, Icon Design, Ubiquitous, Augmented and Virtual Reality.

COURSE LEARNING OUTCOME (CLO)	Blooms Taxonomy Level	PROGRAM LEARNING OUTCOME (PLO)
Explain context of HCI and different measures forevaluation.	C-2	2
Apply the principles of good design for people from theperspective of age and disabilities.	C-3	3
Analyze techniques for user centred design for a mediumsized software.	C-5	4
Evaluate the usability of a medium size software userinterface.	C-5	4

Professional Ethics

Course Content: Computing Profession, Computing Ethics, Philosophy of Ethics. The Structure of Organizations, Finance and Accounting, Anatomy of a Software House, Computer Contracts, Intellectual Property Rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse and the Criminal Law, Regulation and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct, ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Describe moral and ethical concepts in professional practices/organizationsand standard codes of conduct/ethics.	C-2	8

Explain the structure of different organizations with respect to implementation/ consideration of professional ethics and societal concerns	C-2	6
Evaluate multiple ethical/unethical situations in different contexts.	C-6	12
Demonstrate effective team membership skills and contribute collaboratively with diverse team environment	C-3	7
Communicate effectively in written and spoken English to transfer complex knowledge related to professional behaviour to technical and non-technical audiences.	A-2	10

Information System and Data Processing

Course Contents: Introduction to Information Systems (ISs) and digital firm, Information Systems of a digital firm Business perspective on ISs. Dimensions of ISs; Organizations, Technology, Management, Management Levels in an organization, Major types of ISs from management point of view, Enterprise Applications, Business perspective on ISs, E-commerce and the internet, The Mobile digital platform and mobile e-commerce, Managing Project Risk.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Describe the role that information systems play in business operations, management, and strategy.	C-2	11
Analyse how common software, hardware, database, and networking applications can be applied to business problems.	C-4	2
Differentiate between traditional computer file systems and current database management systems	C-4	2
Describe the contemporary approaches to information system and its business function point of view	C-2	1
Analyze business processes and the impact of computer use on society.	C-4	6

Organizational Behaviour

Course Contents: Introduction to organizational behavior, society diversity, ethics, individual personalities and behaviour, Organizational Culture, Motivation in the Workplace, Managing Stress and Emotions, Communication in the Workplace, Managing Stress and Emotions, Communication in the Workplace, Group Dynamics, Managing Groups and Teams, Conflict and Negotiation, Leadership, Organizational Structure

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Describe the general history of management theory and practice and frame how organizational behavior has developed from these into a discrete field	C-2	6
Describe organizational behavior and differentiate between the three levels of influence	C-2	8
Describe contemporary issues and topics in organizational behavior	C-2	12

Marketing and Management

Course Contents: Introduction to Project Management, the Project Management and Information Technology Context, the Project Management Process Groups, Project Integration Management, Project Scope Management. Project Time Management, Project Cost Management, Project Quality Management, Project Human Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management, Project Management Tools.

Course Learning Outcome(s) - CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Demonstrate critical thinking and focus on managerial problems in an articulate way to figure out the solution	C-3	6

Identify the significance of the management process and know the contemporary management practice in different applications	C-1	11
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Information security

Course Contents: Introduction to Information Assurance and security, Information security Principles, Standards of Information Assurance, Terms related to Information Security, Cyber Security, Cyber security threats and measures, Cryptography, Cryptography types, Authentication and Signature Techniques, Typical Network Attacks and Threats from the Internet, Passive Measures to Ward off Network Attacks, Active Measures to Safeguard an Enterprise Network.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the Information Security Principles	C-2	1
Describe the concepts of cryptology, cyber security, and network concepts.	C-2	1
Analyse case studies for Designing and Auditing a Security System	C-4	2

Software Re-Engineering

Course Contents: Software Life cycle, Corrective maintenance and its techniques, Preventive maintenance and its techniques, Program Comprehension: familiar code reading, Program Comprehension: unfamiliar code reading, Program Comprehension: Tools for program comprehension, Program slicing, Evolution of Legacy Systems, Program translation, Reengineering requirements, Reengineering software architecture, Data-Oriented Challenges to Evolution.

Course Learning Outcome(s) – CLO	Bloom’s Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the concepts and technique of software reengineering.	C-2	1
Apply reengineering techniques to maintain and modify softwaresystems.	C-3	3

Analyze and understand maintenance related problems associated with object-oriented software systems.	C-4	2
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Software Construction

Course Contents: Introduction to languages, natural languages Descriptive definition of a language, Recursive Definition of Languages, Regular Expressions, Finite automata, Finite automata Transition Graphs, Kleene's Theorem and proofs, NFA -Formal definition, Language of an NFA, Equivalence of DFAs and NFAs, Context-free Grammars (CFGs), Definition, Relationship between parse trees and derivations, Phases of Compilers, Translation Schemes, Lexical Analysis (Scanning), Parsing, Introduction to languages, natural languages Descriptive definition of a language.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Explain the concept of languages in software construction	C-2	1
Design regular expressions, context free grammar and automata	C-3	2
Carryout the compiler phases for real time problems	C-3	3

Analysis of Algorithm

Course Contents: Introduction; role of algorithms in computing, Analysis on nature of input and size of input Asymptotic notations, Big-O, Big Ω , Big Θ , little-o, little- ω , Sorting Algorithm analysis, Loop invariants, Recursion and recurrence relations, Algorithm Design Techniques, Brute Force Approach, Divide-and-conquer approach, Merge, Quick Sort, Greedy approach, Dynamic programming, Elements of Dynamic Programming, Search trees; Heaps, Hashing; Graph algorithms, shortest paths, sparse graphs, String matching, Introduction to complexity classes Architecture.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
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Explain the basic concepts in algorithmic analysis	C-2	1
Apply algorithmic analysis & design principles to a problem	C-3	3
Analyse sorting algorithms	C-4	4
Explain search trees algorithms and their analysis	C-2	1

Introduction To Information and Communication Technology

Course Contents: Introduction to Computer Systems, Looking inside the computer systems, Interacting with your Computer, How do computers represent data, Binary Arithmetic, Boolean algebra: AND, OR, NOT, Processing in a computer, Factors affecting processing speed, Algorithms, flowchart, pseudo code, basic programming techniques, Operating system basics, Networking basics LAN, WAN, How to write simple program in C language.

Course Learning Outcome(s) – CLO	Bloom's Taxonomy Level	Program Learning Outcome(s) - PLO
Explain basic computer organization and functions of various computer hardware and software components.	C-2	1
Explain modern computer security risks, digital privacy and basic of computer networks	C-2	1,8
Practice hardware components, operating systems and Office Automation tools	P-3	5