

1. OBE components of BS (AI) Program

1.1 University Vision

Hazara University intends to be a standard university providing affordable quality educational opportunities for students to develop scientific, socio-culture, economic and political leadership, through learner-centered teaching and research, while strengthening their identity at Regional, National and International level.

1.2 Dept of Computer Sc and IT: Mission:

The mission of the Department of CS&IT at Hazara University is to provide affordable and excellent teaching and research environment to produce graduates who are distinguished from others because of their core competency in the discipline and associated attributes. These include professional competence, research, entrepreneurship, humanistic outlook, ethical rectitude, pragmatic approach to problem solving, managerial skills and ability to respond to the challenge of socio-economic development.

1.3 The Program Educational Objectives (PEOs)/PO of BS (AI) are:

PEO-1: Graduates utilizing their skills and knowledge to solve complex problems in real-world settings.

PEO-2: Graduates practicing in the area of Artificial Intelligence in a socially and ethically responsible way.

PEO-3: Graduates demonstrating lifelong learning skills in Artificial Intelligence and allied disciplines.

PEO-4: Communicate effectively, demonstrate leadership, and work collaboratively in diverse teams/organizations

1.4 List of BS(AI) Courses' CLOs, and their mapping to GAs and Course Contents

Sr. No	Code	Course Title	Credits hours	Distribution
1	CS100	Programming Fundamentals	3+1	Computing Core
2	CS102	Object Oriented Programming	3+1	
3	CS200	Data Structure and Algorithms	3+1	
4	CS201	Discrete Structures	3	
5	CS202	Operating System	3+1	
6	SE300	Database Systems	3+1	
7	SE301	Software Engineering	3	
8	CS302	Computer Networks	2+1	
9	CS402	Information Security	3	
10	CS400	FPY-I CS400	3	
11	CS401	FPY-II CS401	3	
12	ENG100	English 1	3	General Education
13	ENG200	English 2	3	
14	ENG300	English 3	3	
15	CS340	Professional Practices	3	
16	CS100	Introduction to computing	3	
17	ISL100	Islamic studies	3	
18	MTH101	Mathematics (Calculus)	3	Mathematics and Science Foundation Course
19	STAT202	Probability & Statistics	3	
20	MTH210	Linear Algebra	3	
21	MTH202	Differential Equation	3	
22	SOC100	Sociology	3	University Elective
23	PSY100	Psychology	3	
24	MGT100	Principles of Management	3	
25	ECON100	Basic Economics	3	
26	CS312	Artificial Intelligence	3-1	Computer Science Core
27	CS211	Digital Logic Design	3-1	
28	CS311	Analysis of Algorithms	3-0	
29	CS210	Computer Organization & Assembly Language	3-1	
30	CS410	Parallel & Distributed Computing	2-1	
31	AI210	Programming for Artificial Intelligence	2+1	Artificial Intelligence Core
32	AI310	Artificial Neural Networks	2+1	
33	AI311	Knowledge Representation & Reasoning	3	
34	AI312	Machine Learning	2+1	
35	AI313	Computing Vision	2+1	
36	AI314	Natural Language Processing	3	
37	CS220	Cloud Computing	3	Elective Courses
38	CS322	Digital Image Processing	3+1	
39	AI322	Deep Learning	3	
40	AI325	Knowledge Based Systems	3	

Distribution of COMMON COURSES for BS Computing Core

Code	Course Title	Credit Hours	Category
CS100	Programming Fundamentals	3+1	Computing Core
CS102	Object Oriented Programming	3+1	Computing Core
CS200	Data Structure and Algorithms	3+1	Computing Core
CS201	Discrete Structures	3	Computing Core
CS202	Operating System	3+1	Computing Core
SE300	Database Systems	3+1	Computing Core
SE301	Software Engineering	3	Computing Core
CS302	Computer Networks	2+1	Computing Core
CS402	Information Security	3	Computing Core
CS400	FPY-I CS400	3	Computing Core
CS401	FPY-II CS401	3	Computing Core

Course Code: CS-101

Course Name: Programming Fundamental

Credit Hours: 4(3+1)

Pre-requisites: None

Course Introduction:

This course provides fundamental concepts of programming. The course is prerequisite to many other courses, therefore, students are strongly advised to cover all contents and try to achieve CLOs to the maximum possible level. The course may be taught as language independent but the practical/Lab will be done using C++.

Course Objectives:

The objective of course is to introduce a disciplined approach to Problem solving methods and algorithm development. The aim is to teach the syntax and vocabulary of a programming language like C++. The significant philosophies and logical programming, including models for I/O, processing, and all related terminology will be taught. Simple programs will be constructed, using a number of different logical, calculation and algorithm.

Essential Topics to be covered in the Course:

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, multidimensional lists, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations.

Course Learning Outcomes (CLO's):

Upon successful completion of the course the student will be able to:

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1	Understand basic problem solving steps and logic constructs	GA-2
2	Apply basic programing concepts	GA-2

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
3	Design and implement algorithms to solve real world problems	GA-4

1. Starting out with Programming Logic & Designs, 4th Edition, Tony Gaddis,
2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
3. Object Oriented Programming in C++ (4th Edition) by Robert Lafore
4. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Course Code: CS102

Course Title: Object Oriented Programming

Credit Hours: 3

:

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Demonstrate fundamental principles and concepts of object-oriented programming. Understanding	GA-2
2.	Apply the concepts of object-oriented programming principles (abstraction, inheritance, and polymorphism.) along with interfaces to solve a real-world problem.	GA-3
3.	Apply event handling model to develop event-driven programs that respond to user events.	GA-3
4.	Apply the concept of exception handling and file-based approaches to develop error proven & to store data for users/programmers.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Implement a small module utilizing Object-Oriented design	GA-4
2.	Develop a file-based project for a real-world problem in a C++ environment.	GA-5
3.	Develop a exception handling based projects for real world problem using C++ environment.	GA-5

Course Contents

Evolution of OO, OO concepts and principles, problem solving in OO paradigm, OO programme design process, classes, methods, objects, and encapsulation; constructors and destructors, operator and function overloading, virtual functions, derived classes, inheritance and polymorphism. I/O and file processing, exception handling.

Reference Materials:

1. Object Oriented Programming in C++, 3rd Edition by Robert Lafore
2. C++: How to Programme, Deitel and Deitel, 10/e, Pearson.

Course Code: CS200

Course Title: Data Structures and Algorithms

Credit Hours: 4 (3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Elaborate concepts of data, types of data, basic operations on data and logical organizations of data.	GA-2
2.	Elaborate different organizations of data, their types and their relevant advantages and disadvantages, concept of processing time and memory requirements of data and the concepts of time and space complexity of computer programs.	GA-2
3.	Enabling how to select a data organization for a given set of data keeping in view the required operations on the data.	GA-3
4.	Enabling how to write an algorithm for a given operation.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Understanding of how to convert an algorithm into a program using some specific programming language.	GA-5
2.	Implementing algorithms	GA-4
3.	Practicing and evaluating the time and space complexity for different programs for the same operation.	GA-3
4.	Implementing and elaborating recursive programs.	GA-2

Course Contents

Abstract data types, complexity analysis, Big Oh notation, 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, memory management and garbage collection

Reference Materials:

1. Data Structures and Algorithm Analysis in Java by Mark A. Weiss
2. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
3. Data Structures and Algorithms in C++ by Adam Drozdek
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss

Course Code: CS-201

Course Title: Discrete Structures

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Implement various data structures and their algorithms and apply them in implementing simple applications	GA-4
2.	Analyze simple algorithms and determine their complexities.	GA-3
3.	Apply the knowledge of data structure to other application domains.	GA-3
4.	Design new data structures and algorithms to solve problems.	GA-4

Course Contents
Mathematical reasoning, 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.

Reference Materials:

1. Discrete Mathematics and Its Applications, 7th edition by Kenneth H. Rosen
2. Discrete Mathematics with Applications, 4th Edition by Susanna S. Epp
3. Discrete Mathematics, 7th edition by Richard Johnson Baugh
4. Discrete Mathematical Structures, 4th edition by Kolman, Busby & Ross
5. Discrete and Combinatorial Mathematics: An Applied Introduction by Ralph P. Grimaldi
6. Logic and Discrete Mathematics: A Computer Science Perspective by WinifredGrassman

Course Code: CS202

Course Title: Operating System

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Elaborate concepts and principles of operating systems and identify the core functions of the Operating Systems	GA-2
2.	Analyzing the issues of Process Management including process structure, multiprocessing, synchronization, scheduling and communication.	GA-3
3.	Demonstrating memory management issues including advance techniques of paging, segmentation and virtual memory.	GA-3
4.	Demonstrating the operations of various File Management Algorithms.	GA-3
5.	Discuss the issues related to I/O Sub-systems, Threats and specialized operating systems.	GA-2

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Operate basic services and functionality of operating systems.	GA-8
2.	Simulating the concepts of process management, memory management and file management.	GA-4
3.	Accessing basic OS commands and OS External Commands using C/C++ coding.	GA-2
4.	Accessing I/O devices using int86() function of C/C++ without OS functions	GA-2

Course Contents

Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading 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

Reference Materials:

1. Operating Systems Concepts, 9th edition by Abraham Silberschatz
2. Modern Operating Systems, 4th edition by Andrew S. Tanenbaum
3. Operating Systems, Internals and Design Principles, 9th edition by William StallingsWu

Course Code: CS300

Course Title: Database System

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain database concepts and principles.	GA-2
2.	Apply the concept of domain and tuple relational calculus.	GA-3
3.	Apply data modeling and normalization techniques to design database for small to medium size enterprise	GA-4
4.	Describe the principles of transaction management.	GA-2
	Course Learning Outcome (CLO's) of Lab	
5.	Apply data processing operations on both relational and non-relational DBMS.	GA-5
6.	Develop a database system for medium size enterprise in a team environment.	GA-4

Course Contents

Unit Topic 1. Databases & Information Systems: Basic Concepts, Evolution, Advantages & Disadvantages, Database Environment, Approaches & Roles; Components; Architecture; Functions; Data Dependences, and Applications. 2. Relational Model: Relation, Domains, Properties, Attributes; Relational Keys; DB Schema; and Integrity Constraints. 3. Relational Algebra (Operations): Unary, Set, Join, Division, Aggregation & Grouping; and Relational Calculus: Domain & Tuple. 4. Data Modeling: Conceptual Models, Relational Database Design; E-R Model; and Enhanced E-R Model. 5. Normalization: Purpose, Data Redundancy & Anomalies; Process: First Normal Form, Second Normal Form, Third Normal Form, and Boyce-Codd Normal Form. 6. SQL: DDL, DML, DCL; Views; Materialized Views; and Database Authorization. 7. Non-relational / No SQL Databases: MongoDB as NoSQL Database; MongoDB Sharing & Replication; and Document Model. 8. Transaction Management: Support, Failure & Recovery, Concurrency Control, and Transaction & Storage.
--

Course Code: CS301

Course Title: Software Engineering

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Describe various software engineering processes and activities	GA-4
2.	Apply the system modeling techniques to model a medium size software systems	GA-5
3.	Apply software quality assurance and testing principles to medium size software systems	GA-3
4.	Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation, and risk analysis	GA-7

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

Reference Materials:

1. Software Engineering, Sommerville I., 10th Edition, Pearson Inc., 2014
2. Software Engineering, A Practitioner's Approach, Pressman R. S.& Maxim B. R., 8th Edition, McGraw-Hill, 2015

Course Code: CS302

Course Title: Computer Networks

Credit Hours: 4(3+1)

S. No	Course Learning Outcomes (CLO's of Theory)	Graduate Attribute
1	Describe the key terminologies and technologies of computer networks	GA-2
2	Explain the services and functions provided by each layer in the Internet protocol stack.	GA-4
3	Identify various internetworking devices and protocols and their functions in a networking	GA-3
4	Analyze working and performance of key technologies, algorithms and protocols	GA-3
5	Build Computer Network on various Topologies	GA-4

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.

Reference Materials:

1. Computer Networking: A Top-Down Approach Featuring the Internet, 6th edition by James F. Kurose and Keith W. Ross
2. Computer Networks, 5th Edition by Andrew S. Tanenbaum
3. Data and Computer Communications, 10th Edition by William Stallings
4. Data Communication and Computer Networks, 5th Edition by Behrouz A. Forouzan

Course Code: CS302

Course Title: Computer Networks

Credit Hours: 4(3+1)

S. No	Course Learning Outcome (CLO's) of Lab	Graduate Attribute
1	Analyze working and performance of key technologies, algorithms and protocols	GA-3
2	Build Computer Network on various Topologies	GA-4

Course Code: CS402

Course Title: Information Security

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Explain key concepts of information security such as design principles, cryptography, risk management, and ethics	GA-9
2.	Discuss legal, ethical, and professional issues in information security	GA-8
3.	Apply various security and risk management tools for achieving information security and privacy	GA-4
4.	Identify appropriate techniques to tackle and solve problems in the discipline of information security.	GA-3

Course Contents
Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, key management, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.

Reference Materials:

1. Computer Security: Principles and Practice, 3rd edition by William Stallings
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord
3. Computer Security, 3rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition

General Education List of Courses

Code	Course Title	Credit Hours	Category
ENG100	English-1 (English Composition & Comprehension)	3	General Education
ENG200	English-2 (Communication & Presentation Skills)	3	General Education
ENG300	English 3	3	General Education
CS340	Professional Practices	3	General Education
CS100	Introduction to computing	3	General Education
ISL100	Islamic studies	3	General Education

Course Code: ENG100

Course Title: English-1 (English Composition & Comprehension)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Master Written Communication Skills	GA-1
2.	Identify and Correct Sentence Errors	GA-2
3.	Enhance Oral Communication and Presentation Skills	GA-3

Course Contents
Paragraph and Essay Writing, Descriptive Essays; Sentence Errors, Persuasive Writing; How to give presentations, Sentence Errors; Oral Presentations, Comparison and Contrast Essays, Dialogue Writing, Short Story Writing, Review Writing, Narrative Essays, Letter Writing

Reference Material

1. JohnE. Warriner. Warriner's English Grammar and Composition.
2. William Strunk Jr, The Elements of Style
Workbook: Writing Strategies with Grammar Book, Classical Edition, 2017

Course Code: ENG-200

Course Title: English-2 (Communication & Presentation Skills)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1	To enhance students' linguistic command, so they could communicate effectively in diversified socio-cultural situations; create larger stretches of interactive text in speech and writing; and identify and repair any instances of potential communication break-up	GA1
2	It will focus on students' ability to effectively convey and exchange information in cross-cultural, international, and multinational milieu necessitated by the emergence of global society.	GA2
3	The course will able the learners to communicate effectively in the target language.	GA 4

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.

Reference Materials:

1. Practical Business English, Collen Vawdrey, 1993, ISBN = 0256192740
2. Effective Communication Skills: The Foundations for Change, John Nielsen, 2008,

Course Code: CS423

Course Title: English 3

Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Augment proficiency in technical writing in order to sensitize them to the dynamics, challenges, and needs of the modern world characterized by technologically advanced social, cultural and corporate settings.	GA8
2.	Effectively convey and exchange information in cross cultural, international and multinational milieu necessitated by the emergence of global society.	GA7

Course Contents

Technical writing, overview/ strategies/Do's and Don'ts, Technical vocabulary, Language technicalities, steps to effective writing, Common Writing Errors, Proofreading and editing, memo writing, Letter writing, Email writing, Report writing, Minutes Taking, User Manuals, Presentation Skills, CV and Cover Letters, Interview Skills

Course Code: CS241

Course Title: Professional Practices

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to Understand and Apply Ethical Principles in Computing	GA-1
2.	Students will be able to Analyze and Evaluate Organizational Structures and Practices within the Computing Industry	GA-2
3.	Students will be able to apply legal and professional responsibilities in computing	GA-4
4.	Students will be able to use social and professional accountability in the computing profession	GA-3

Course Contents

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 Code: CS100

Course Title: Introduction to Computer

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand basics of computing technolog	GA-1
2.	Do number systems conversions and arithmetic	GA-2
3.	Have knowledge of types of software	GA-2
4.	Have knowledge of computing related technologies	GA-3

Course Contents

Brief history of Computer, Four Stages of History, Computer Elements, Processor, Memory, Hardware, Software, Application Software its uses and Limitations, System Software its Importance and its Types, Types of Computer (Super, Mainframe, Mini and Micro Computer), Introduction to CBIS (Computer Based Information System), Methods of Input and Processing, Class2. Organizing Computer Facility, Centralized Computing Facility, Distributed Computing Facility, decentralized Computing Facility and Input Devices. Keyboard and its Types, Terminal (Dump, Smart, Intelligent), Dedicated Data Entry, SDA (Source Data Automation), Pointing Devices, Voice Input, Output Devices. Soft- Hard Copies, Monitors and its Types, Printers and its Types, Plotters, Computer Virus and its Forms, Storage Units, Primary and Secondary Memories, RAM and its Types, Cache, Hard Disks, Working of Hard Disk, Diskettes, RAID, Optical Disk Storages (DVD, CD ROM), Magnetic Types, Backup System, Data Communications, Data Communication Model, Data Transmission, Digital and Analog Transmission, Modems, Asynchronous and Synchronous Transmission, Simplex. Half Duplex, Full Duplex Transmission, Communications, Medias (Cables, Wireless), Protocols, Network Topologies (Star, Bus, Ring), LAN, LAN, Internet, A Brief History, Birthplace of ARPA Net, Web Link, Browser, Internet Services provider and Online Services Providers, Function and Features of Browser, Search Engines, Some Common Services available on Internet. Ethics in information security, privacy and anonymity of data.

Reference Materials:

1. Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA
2. Livesley, Robert Kenneth. An introduction to automatic digital computers. CambridgeUniversity Press,2017.
3. Zawacki-Richter, Olaf, and Colin Latchem. "Exploring four decades of research in Computers & Education." Computers & Education 122 (2018): 136-152.
4. Sinha, Pradeep K., and Priti Sinha. Computer fundamentals. BPB publications, 2010.
5. Goel, Anita. Computer fundamentals. Pearson Education India, 2010

Course Code: ISL100

Course Title: Islamic Studies

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Capability to enhance the knowledge of Islam.	GA-1
2.	Capability to understand the basic concept of Islam and its sources.	GA-2
3.	Capability to understand ethical responsibility and Religious life.	GA-9
4.	The ability to understand Moral, economic & practical issues in Islamic perspective.	GA-8

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

Mathematics & Science Foundation Courses

Code	Course Title	Credit Hours	Category
MTH101	Mathematics(Calculus)	3	Mathematics & Science Foundation
STAT202	Probability & Statistics	3	Mathematics & Science Foundation
MTH210	Linear Algebra	3	Mathematics & Science Foundation
MTH202	Differential Equations	3	Mathematics & Science Foundation

Course Code: MTH101

Course Title: Calculus & Analytical Geometry

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	CLO1: Familiarity with elementary algebraic and transcendental functions which arise in computer science	GA2
2.	Relate the concepts of calculus of single variable to their graphical, numerical and symbolic representations	GA7
3.	Use differentiation to solve related rates and optimization problems which model real-world situations.	GA3
4	Apply Fundamental Theorem of Calculus to calculate the area between the curves and volume of solids	GA4

Course Contents

Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of finding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential calculus; Concept and idea of differentiation, Geometrical and Physical meaning of derivatives, Rules of differentiation, Techniques of differentiation, Rates of change, Tangents and Normal's lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation; Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity, Integral calculus; Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve, Analytical Geometry; Straight lines in R^3 , Equations for planes
--

Course Code: Stat 124

Course Title: Probability and Statistics

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire the basic knowledge of the discipline of Statistics and Applied in field of AI.	GA-1
2.	Evaluate and interpret basic descriptive statistics. Display, Interpret data graphs	GA-4
3.	Acquire the basic knowledge of statistical estimators, probability and probability distribution functions and use to developed statistical soft ware's,	GA-5
4.	Understand the concepts of basic techniques of measuring the uncertainty problem and solve the real life problems,	GA-10

Course Contents
The nature and scope of the Statistics, Variables and their types, Data and its sources, Scales of measurements ,Tabulation and classification of data ,Graphs and Charts Measures of Central Tendency ,Measures of Dispersion, Random Experiment Counting Techniques, Probability Theory, Laws of Probability, Random Variable, Probability Distributions

Reference Materials:

1. Spiegel, M. R., Schiller, J. J., & Srinivasan, R. A. (2009). "Probability and statistics", McGraw-Hill.
2. Clark, G.M. and Cooke, D. (2011), "A Basic Course in Statistics" 5th ed, Wiley.
3. Walpole, R. E. (1982). "Introduction to Statistics", 7th ed, Macmillan Publishing Co., Inc. New York.
4. Walpole, R.E., Myers, R.H and Myers, S.L. (2017), "Probability and Statistics for Engineers and Scientist", 9th ed, Pearson.
5. Weiss, N.A. (2016), "Introductory Statistics", 10th ed, Pearson

Course Code: CS

Course Title: Linear Algebra

Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to explain and apply the fundamental concepts of linear algebra	GA-2
2.	They will be able to understand the structure and properties of vector spaces	GA-3
3.	They will be able to master orthogonal transformations and the concept of inner product spaces	GA-4
4.	Students will develop the ability to calculate eigenvalues and eigenvectors, understand their significance in linear transformations	GA-54

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

Reference Materials:

1. Elementary Linear Algebra by Howard Anton
2. Linear Algebra and its Applications by Gibert Strang

Course Code: MTH202

Course Title: Differential Equations

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Identify, analyze and subsequently solve physical situations whose behavior can be described by ordinary differential equations.	GA-1
2.	Determine solutions to first order separable differential equations	GA-3
3.	Determine solutions to first order linear differential equations.	GA-2
4.	Determine solutions to first order exact differential equations and second order linear homogeneous and non-homogeneous differential equations with constant coefficients	GA-4

Course Contents

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. Ordinary Linear Differential Equations; Homogeneous Linear Equations of the Second Order, Homogeneous Second-Order Equations with Constant Coefficients, General Solution, Real Roots, Complex Roots, Double Root of the Characteristic Equation, Differential Operators, Cauchy Equation, Homogeneous Linear Equations of Arbitrary Order, Homogeneous Linear Equations of Arbitrary Order with Constant Coefficients, Non-homogeneous Linear Equations. Modelling of Electrical Circuits. Systems of Differential Equations. Series Solutions of Differential Equations. Partial Differential Equations: Method of Separation of variables, wave, Heat & Laplace equations and their solutions by Fourier series method.

Reference Materials:

1. Advanced Engineering Mathematics Michael, G.th edition, Erwin, K. 1993, John Wiley&1996, Prentice Hall Publishers. Sons
2. Advanced Engineering Mathematics, 7 Inc.
3. A First Course in Differential Equation Zill. Prindle. Weber. Schmidt.1996. Brooks/Cole

University Electives

Code	Course Title	Credit Hr.	Category
SOC100	Sociology	3	University Electives
PSY100	Psychology	3	University Electives
MGT100	Principles of Management	3	University Electives
ECON100	Basic Economics	3	University Electives

Course Code: SOC100

Course Title: Sociology

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand Sociological Concepts and Theories:	GA-1
2.	Analyze Social Structures and Processes	GA-2
3.	Evaluate the Dynamics of Social Change and Integration	GA-3
4.	Apply Sociological Perspectives to Contemporary Issues	GA-4

Course Contents
Scope of Sociology, Importance of Sociology, Topic culture, Structural Functionalism, Social Conflict, Symbolic Interactionism & Test Conflict, Social Control, Agents of Social Control, Social Stratification & Social Mobility, Social Institution, Characteristics & Function, Family Religion Assignment Religion, Socialization, Agents of Socialization, Accommodation, Assimilation, Acculturation, Caste System Class System

Course Code: PSY-100
Course Title: Psychology
Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, the students will be able to understand the fundamental theories and concepts that underpin various psychological perspectives, including behaviorism, psychoanalysis, cognitive psychology, and humanistic psychology	GA1
2.	To analyze the key principles of research methods employed in psychology, such as experimental design, surveys, case studies, and observational techniques	GA4
3.	Enable students to implement the Psychological concepts in the Human Computer Interaction (HCI) to design usable things.	GA8

Course Contents
understanding psychology, research methods, biological basis of behavior, cognition, language, intelligence, creativity, sensation, perception, learning, memory, motivation, emotions

Course Code: MGT-100

Course Title: Principles of Management

Credit Hours: 3

S. No.	Course earning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to specify how the managerial tasks of planning, organizing, and controlling can be executed in a variety of circumstances.	GA-1
2.	They will be able assess global situation, including opportunities and threats that will impact management of an organization.	GA-3
3.	The course will help them to integrate management principles into management practices.	GA-2
4.	They will be able to determine the most effective action to take in specific situations and evaluate approaches to addressing issues of diversity.	GA-4

Course Contents
Basic concept, Organization, Organizational type, Component of organization, Definition and process of Mgt. Other concept of management. SWOT analysis of organization, Foundation of basic element in planning, Decision making, Definition decision / nature of decision, Strategic management, Organizational structure, Human resources management, Leadership, team work and group behavior, staffing, Controlling, Definition of controlling, Nature of controlling Importance of controlling, Controlling process

Course Code: ECON-100

Course Title: Basic Economics

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand consumer, Producer behavior, macroeconomic indicators issues, and Environmental economics aspects of a country.	GA-1
2.	Apply graphical analysis for a variety of economic situations	GA-4
3.	Calculate and interpret elasticities.	GA-3
4.	Define and derive short-run and long-run production costs	GA-5
5.	Explain various market structures	GA-7

Course Contents

Introduction to economics school of thoughts; Microeconomics, macroeconomics, Scarcity, Consumer theory; Demand and Law of demand, schedule, graph, limitations; Utility, Law of diminishing marginal Utility, graph, limitations; Supply, law of supply, schedule, graph, determinants of supply; Equilibrium point. Surplus and shortage; Elasticity, types of elasticity; Indifference curve, properties of Indifference curve; Budget line, Marginal rate of substitution; Utility maximization through IC and budget line; Producer Behavior, objective of the producer; Cost, types of cost; Revenue , types of Revenue , Profit; Law of return to scale; Market, Types of markets; Markets based on economic competition (Introductory treatment); Basic Macroeconomics concepts; GDP, GNP , NNP , National Income, PC; Circular flow of national income; Real GDP vs Nominal GDP; Inflation , types of inflation and its causes; Consumer price index and its relationship with inflation; Economic problems of Pakistan; Interest rate, and its types; Unemployment and its types; Economic growth vs Economic development; Monetary Policy of Pakistan; Fiscal policy; Introduction to taxation; Sustainable Development Goals;

Reference Materials:

1. Gujarati, D. J. - Basic Econometrics – 4th Edition (2003) McGraw-Hill Company.
2. Maddala, G. S. – Econometrics - (1988) – McGraw-Hill Company.
3. Koutsoyiannis, A.- Theory of Econometrics - 2nd Edition (1977) –McMillan

Computer Science Core List of Courses

Code	Course Title	Credit Hr.	Category
CS312	Artificial Intelligence	3-1	Computer Science Core
CS211	Digital Logic Design	3-1	Computer Science Core
CS311	Analysis of Algorithms	3-0	Computer Science Core
CS210	Computer Organization & Assembly Language	3-1	Computer Science Core
CS410	Parallel & Distributed Computing	2-1	Computer Science Core

Course Code: CS312

Course Title: Artificial Intelligence

Credit Hours: 3 (2)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand the fundamental constructs of Python programming language.	GA-2
2.	Understand key concepts in the field of artificial intelligence.	GA-2
3.	Implement artificial intelligence techniques and case studies	GA-4

Course Contents

An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min-max algorithm, Alpha beta pruning, Game-playing); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learning from examples; Natural Language Processing; Recent trends in AI and applications of AI algorithms. Lisp & Prolog programming languages will be used to explore and illustrate various issues and techniques in Artificial Intelligence.

Reference Materials:

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", 3rd ed, PrenticeHall, Inc., 2015.
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.

Course Code: CS423

Course Title: Artificial Intelligence

Credit Hours: 3 (1)

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate attributes
1.	Explain how simple AI Algorithms can be designed	GA-2
2.	Implement artificial intelligence techniques and case studies	GA-5

Course Code: CS352

Course Title: Digital Logic Design

Credit Hours: 4(3)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits	GA-1
2.	Demonstrate the skills to design and analyze both combinational and sequential circuit using a variety of techniques	GA-2
3.	Apply the acquired knowledge to simulate and implement small-scale digital circuits	GA-3
4.	Understand the relationship between abstract logic characterizations and practical electrical implementations.	GA-4

Course Contents
Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey 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

Reference Materials:

1. Digital Fundamentals by Floyd, 11/e.
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e

Course Code: CS352

Course Title: Digital Logic Design

Credit Hours: 4(1)

S. No.	Course Learning Outcome (CLO's) Lab	Graduate attributes
1.	Apply the acquired knowledge to simulate and implement small-scale digital circuits	GA-3
2.	Understand the relationship between abstract logic characterizations and practical electrical implementations.	GA-4

Course Code: CS-311

Course Name: Analysis of Algorithms

Credit Hours: 3(3+0)

Pre-requisites: Data Structures & Algorithms

Course Introduction:

Detailed study of the basic notions of the design of algorithms and the underlying data structures. Several measures of complexity are introduced. Emphasis on the structure, complexity, and efficiency of algorithms.

Course Objectives:

The course aims to provide familiarity with general algorithmic techniques, performance measures, analysis tools and problem areas. In this course, we will focus on developing an understanding of the algorithmic design process: how to identify the algorithmic needs of an application and apply algorithmic design techniques to solve those problems. The students will also learn how to identify problems for which no exact, efficient algorithm is known.

Essential Topics to be covered in the course:

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.

Course Learning Outcomes(CLO's):

Upon successful completion of the course the student will be able to:

CLO #	Course Learning Outcome (CLO's)	Graduate Attributes
-------	---------------------------------	---------------------

1.	Explain what is meant by “best”, “expected”, and “worst” case behavior of an algorithm	GA-1
2.	Elaborate different organizations of data, their types and their relevant advantages and disadvantages.	GA-1
3.	Determine informally the time and space complexity of simple algorithms plus List and contrast standard complexity classes.	GA-3
4	Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms	GA-2
5	Use of the strategies(brute-force, greedy, divide-and-conquer, and dynamic programming) to solve an appropriate problem	GA-2
6	Solve problems using graph algorithms, including single-source and all-pairs shortest paths, and at least one minimum spanning tree algorithm also Trace and/or implement a string-matching algorithm	GA-3

1. Introduction to Algorithms (4th edition) by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein
2. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos,
3. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne

Course Code: CS- 210

Course Title: Computer Organization and Assembly Language

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Acquire the basic knowledge of computer organization, computer architecture and assembly language	GA-1
2.	Understand the concepts of basic computer organization, architecture, and assembly language techniques	GA-2
3.	Solve the problems related to computer organization and assembly language	GA-3

Course Contents

Introduction to computer systems: Information is bits + context, programs are translated by other programs into different forms, it pays to understand how compilation systems work, processors read and interpret instructions stored in memory, caches matter, storage devices form a hierarchy, the operating system manages the hardware, systems communicate with other systems using networks; Representing and manipulating information: information storage, integer representations, integer arithmetic, floating point; Machine-level representation of programs: a historical perspective, program encodings, data formats, accessing information, arithmetic and logical operations, control, procedures, array allocation and access, heterogeneous data structures, putting it together: understanding pointers, life in the real world: using the gdb debugger, out of-bounds memory references and buffer overflow, x86-64: extending ia32 to 64 bits, machine-level representations of floating-point programs; Processor architecture: the Y86 instruction set architecture, logic design and the Hardware Control Language (HCL), sequential Y86 implementations, general principles of pipelining, pipelined Y86 implementations.
--

Course Code: CS- 210

Course Title: Computer Organization and Assembly Language

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Solve the problems related to computer organization and assembly language	GA-3

Course Code: SE 310

Course Title: Parallel & Distributed Computing

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Learn about parallel and distributed computers.	GA-1
2.	Write portable programs for parallel or distributed architectures using Message-Passing Interface(MPI) library	GA-2
3.	Analytical modeling and performance of parallel programs.	GA-3
4.	Analyze complex problems with shared memory programming with open MP.	GA-2

Course Contents

Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD, multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE)

Reference Materials:

1. Distributed Systems: Principles and Paradigms, A.S. Tanenbaum and M.V. Steen, Prentice Hall, 2nd Edition, 2007
2. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K. Hwang, J. Dongarra and G.C. Fox, Elsevier, 1st Ed.

Course Code:
Course Title: **Parallel & Distributed Computing**
Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Write portable programs for parallel or distributed architectures using Message-Passing Interface(MPI)library	GA-2
2.	Analyze complex problems with shared memory programming with open MP.	GA-2

**Domain Courses for BS(Artificial Intelligence) Artificial
Intelligence CORE (Compulsory)**

Code	Course Title	Credit Hours	Category
AI210	Programming for Artificial Intelligence	2-1	Artificial Intelligence CORE
AI310	Artificial Neural Networks	2-1	Artificial Intelligence CORE
AI311	Knowledge Representation & Reasoning	3	Artificial Intelligence CORE
AI312	Machine Learning	2-1	Artificial Intelligence CORE
AI313	Computing Vision	2-1	Artificial Intelligence CORE
AI314	Natural Language Processing	3	Artificial Intelligence CORE

Course Code: AI210

Course Name: Programming for AI

Credit Hours: 3(3+0)

Pre-requisites: Artificial Intelligence

Course Introduction:

This course aims to introduce standard programming practices and to help develop programming skills necessary for designing and implementing Artificial Intelligence systems. The course introduces classical as well as modern state of the art programming language for Artificial Intelligence, and builds up the necessary programming background for the main courses like Machine Learning, Artificial Neural Networks & Deep Learning, Natural Language Processing, and Speech Processing. This course will help the students of Artificial Intelligence to develop the programming insights and style. The ultimate aim of this course is to help students in using the AI programming language to solve problems of interest to them.

Course Objectives:

1. Introduction to Programming language (Python)
2. Introducing libraries/toolboxes necessary for data analysis

Essential Topics to be covered in the course:

The first objective of the course is to introduce and then build the proficiency of students in AI programming language (Python). The basics include IDE for the language, variables, expressions, operands and operators, loops, control structures, debugging, error messages, functions, strings, lists, object-oriented constructs and basic graphics in the language. Special emphasis is given to writing production quality clean code in the programming language. Once the programming language is properly introduced, the course should introduce some libraries necessary for interpreting, analyzing and plotting numerical data in Python (e.g., NumPy, Matplotlib, Anaconda and Pandas for Python) and give examples of each library using simple use cases and small case studies.

Course Learning Out comes(CLO's):

Upon successful completion of the course the student will be able to:

CLO #	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand the fundamental constructs of Python programming language.	GA-2
2.	Understand and apply the Object-oriented concepts in the python programming language.	GA-2

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
3.	Apply various libraries for plotting, interpreting and analyzing data in Python.	GA-3
4	Build an AI application using deep learning	GA-5

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", 3rd ed, Prentice Hall, Inc., 2015.
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.
3. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. 2009.
4. Severance, C.R., 2016. "Python for everybody: Exploring data using Python 3." CreateSpace Independent Publ Platform.
5. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. "Python programming in context." Jones & Bartlett Pub.
6. McKinney, W., 2012. "Python for data analysis: Data wrangling with Pandas, NumPy, and IPython." O'Reilly Media, Inc.
7. Joshi, P., 2017. "Artificial intelligence with python." Packt Publishing Ltd.
8. Janert, P.K., 2010. "Data analysis with open source tools: a hands-on guide for programmers and data scientists." O'Reilly Media, Inc.

Course Code: AI-312

Course Title: Programming for AI

Credit Hours: 3(2+1)

S. No	Course Learning Outcome (CLO's) of Lab	Graduate Attribute
1	Understand and apply the Object-oriented concepts in the programming language	GA-4
2	Solve and analyze programming and data analysis problems using standard libraries and/or toolboxes of the programming language.	GA-5

Course Code: CS423

Course Title: Artificial Neural Networks and Deep Learning

Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand the fundamentals of neural networks in AI	GA-2
2.	Explain how simple ANNs can be designed	GA-4
3.	Apply ANN for classification Problems	GA-4
4.	Differentiate between different Networks and their learning laws	GA-2

Course Contents
Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification, Gradient descent (Delta) rule, Hebbian, Neo-Hebbian and Differential Hebbian Learning, Drive Reinforcement Theory, Kohonen Self Organizing Maps, Associative memory, Bi-directional associative memory (BAM), Energy surfaces, The Boltzmann machines, Backpropagation Networks, Feedforward Networks; Introduction to Deep learning and its architecture.

Reference Materials:

1. Neural Network Design, 2nd Edition, Martin T. Hagan, Howard, B. Demuth, Mark Hudson Beale and Orlando De Jesus, Publisher: Martin Hagan; 2 edition (September1, 2014), ISBN-10: 0971732116
2. An Introduction to Neural Networks, James A Anderson, Publisher: A Bradford Book (March 16, 1995), ISBN-10: 0262011441

Course Code: AI311

Course Title: Knowledge Representation and Reasoning

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand the fundamentals of knowledge representation and reasoning in deterministic situations	GA-2
2.	Understand the challenges in representing knowledge and reasoning under uncertainty	GA-5
3.	Analyze different situations and apply appropriate knowledge representation frameworks	GA-4
4.	Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems	GA-6

Course Contents

Propositional Logic, First-order Logic, Horn Clauses, Description Logic, Reasoning using Description Logic, Forward and Backward Chaining in Inference Engines, Semantic Networks, Ontologies and Ontology Languages, Logical Agents, Planning, Rule-based Knowledge Representation, Reasoning Under Uncertainty, Bayesian Networks Representation, Inference in Bayesian Networks, Fuzzy Logic, Inference using Fuzzy Rules, Markov Models, Commonsense Reasoning, Explainable AI
--

Reference Materials:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd Ed.)(2015)
2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 2nd Ed, 2017
1. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning,

Course Code: AI312

Course Title: Machine Learning

Credit Hours: 3(2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Describe basic machine learning concepts, theories and application	GA-2
2.	Apply supervised learning techniques to solve classification problems of moderate complexity	GA-4
3.	Apply reinforcement learning algorithms to environments with complex dynamics.	GA-3
4.	Apply reinforcement learning algorithms to environments with complex dynamics.	GA-5
5.	Develop a reasonable-sized project using suitable machine learning techniques.	GA-6

Course Contents

Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Agglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and unlabeled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses. Bagging, boosting.

Reference Materials:

1. Machine Learning, Tom, M., McGraw Hill, 1997.
2. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press, 2012

Course Code: AI-
Course Title: Machine Learning
Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate attributes
1.	Design and Implement supervised and Unsupervised algorithms using python libraries	GA-5
2.	Develop a reasonable size project using suitable machine learning technique	GA-3
3.		GA-4

Course Code: AI-313

Course Title: Computer Vision

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand and explain the field of computer vision in general for different applications, etc.	GA-2
2.	Understand and implement camera calibration	GA-3
3.	To detect, recognize and track different types of the objects in the scene	GA-4
4.	Develop an algorithm for context awareness or scene understanding Implement an algorithm to assemble the extracted features to develop a higher-level perception Implement different algorithms for spatial and frequency domain filtering, feature detection, structure from motion, motion estimation, etc.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Develop experience in using Python Libraries and programming languages (such as MATLAB, Python with Open CV, or other relevant tools libraries like OpenCV and PIL) to implement algorithms and solve computer vision tasks	GA-5

Course Contents

Introduction, Image formation, Spatial and frequency domain processing, Feature detection and extraction, Image registration, Segmentation, Camera calibration, Structure from motion, Motion estimation, Stereo vision, Object detection and recognition, Object tracking, 3D scene reconstruction, Context and scene understanding, Image stitching, Image-based and video-based rendering, High-performance computing paradigms for vision and image processing

Reference Materials:

Text Book:

1. Computer Vision: Algorithms and Applications, by Richard Szeliski.

Reference Book:

2. Multiple View Geometry in Computer Vision, by Richard Hartley and Andrew Zisserman.

3. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce.

4. Digital Image Processing, by Rafael Gonzalez and Richard Woods

Course Code: AI-314

Course Title: Natural Language Processing

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Identify techniques for information retrieval, language translation, and text classification	GA-2
2.	List the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks	GA-3
3.	Define and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each.	GA-4
4.	Simulate, apply, or implement classic and stochastic algorithms for parsing natural language	GA-3

Course Contents
Deterministic and stochastic grammars, parsing algorithms, CFGs, Representing meaning, Semantics, Semantic roles, Temporal representations, Corpus-based methods, N-grams and HMMs, Smoothing and backoff, POS tagging and morphology, Information retrieval, Vector space model, Precision and recall, Information extraction, Language translation, Text classification, categorization, Bag of words model.

Course Code: AI-310

Course Title: Artificial Neural Networks and Deep Learning

Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate attributes
1.	Explain how simple ANNs can be designed	GA-2
2.	Apply ANN for classification Problems	GA-3
3.	Differentiate between different Networks and their learning laws	GA-4

Artificial Intelligence Elective Courses

Code	Course Title	Credit Hr.	Category
CS220	Cloud Computing	3	Artificial Intelligence Elective
CS322	Digital Image Processing	3-1	Artificial Intelligence Elective
AI322	Deep Learning	3	Artificial Intelligence Elective
AI325	Knowledge Based Systems	3	Artificial Intelligence Elective

Course Code: CS42
Course Title: Cloud Computing
Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understanding basic concepts of distributed systems	GA-1
2.	Understanding of cloud computing technologies	GA-2
3.	Understanding of Virtualization and its various flavors	GA-4
4.	Ability to address large scale data processing challenges	GA-3

Course Contents
Introduction to Cloud Computing, History and Background of Cloud Computing , Basics of Computers ,Basics of Data Communication ,Basics of Computer Networking Advanced Topics of Computer Networks ,Virtualization Essential Characteristics of Cloud Computing Benefits of Cloud ,Computing Risks and Challenges of Cloud Computing , Roles and Boundaries of Cloud Computing ,Cloud Service Models Data Storage in Clouds ,Miscellaneous Services of Cloud Computing ,Cloud Deployment Models Service Oriented Architecture ,Cloud Security Threats Trust Issues in Cloud Mechanisms Related to Cloud Infrastructure Service Agreements Cloud Hosting Data Center Design Cloud ,Architecture Specialized Cloud Mechanisms ,Cloud Management Fundamental ,Cloud Architectures Advanced ,Cloud Architectures Cloud Federation Cloud Delivery/Service Models' Perspectives Inter-Cloud Resource Management Cloud Cost Metrics and Pricing Models ,Cloud Service Quality Metrics Cloud Simulator Computer Security Basics Network Security Basics ,Cloud Security Mechanisms Privacy Issues of Cloud Computing Security Issues of Cloud Computing Trust Issues of Cloud Computing Open Issues in Cloud Disaster Recovery in Cloud Computing Migrating to the Cloud Cloud Application Scalability and Resource Scheduling ,Mobile Cloud Computing

Reference Materials:

1. Cloud Computing: Theory and Practice by [Dan C. Marinescu](#) (Author).
2. Cloud Computing: Principles and Paradigms by [Rajkumar Buyya](#) (Editor), [James Broberg](#) (Editor), [Andrzej M. Goscinski](#) (Editor).
3. Cloud Computing: Implementation, Management, and Security by [John Rittinghouse](#) (Author), [James Ransome](#) (Author).
4. Cloud Computing: Concepts and Practices by [Naresh Kumar Bhatt](#), [Pramod Chandra P.](#), [Sehgal](#) (Author).

Course Code: CS423

Course Title: Digital Image Processing

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1	Understand the basics, applications in general, working inside the digital camera, sampling and quantization, image representation, etc.	GA1
2	Implement image enhancement, image segmentation, image transformations, spatial and frequency domain processing, filtering, convolution, image registration, feature detection, pattern recognition, etc.	GA2
3	Evaluate the performance of different image processing algorithms.	GA 4
4	Use software tools for image processing	GA5

Course Contents

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

Reference Materials:

1. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce.
2. Digital Image Processing, by Rafael Gonzalez and Richard Woods.

Course Code: CS

Course Title: Deep learning

Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Apply deep learning algorithms to real-world problems	GA2
2.	Analyze results from deep learning to select appropriate solutions	GA3
	Code the novel neural network architectures from scratch and evaluating the performance on application-specific standard benchmarks	GA5

Course Contents

Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Theory of Generalization; Multi-layer perceptrons, error back-propagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc

Reference Materials:

1. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville (

<http://www.deeplearningbook.org/>)

2. Deep learning with python by Francoise Chollet, ISBN-10: 9781617294433, 2017

Course Code: AI-
Course Title: Deep Learning
Credit Hours: 3 (2+1)

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate attributes
1.	Apply deep learning algorithms to real-world problems	GA-2
2.	Analyze results from deep learning to select appropriate solutions	GA-3
3.		GA-4

Course Code:

Course Title: Knowledge Based System

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Demonstrate a comprehensive understanding of knowledge representation techniques and their applicability in problem-solving.	GA-1
2.	Evaluate and compare different knowledge representation methods, highlighting their advantages and disadvantages.	GA-2
3.	Select and implement appropriate knowledge representation schemes based on specific problem requirements.	GA-3
4.	Develop algorithms for inference and decision-making in knowledge-based systems.	GA-4
5	Analyze the computational complexity and resource requirements of knowledge-based systems, including time and space complexity considerations.	

Course Contents

Knowledge representation techniques (e.g., logic-based, semantic networks, frames, ontologies), Inference mechanisms (e.g., rule-based reasoning, fuzzy logic, Bayesian networks), Knowledge acquisition and validation, Expert systems and their components. Decision support systems, Machine learning techniques for knowledge-based systems, Natural language processing for knowledge extraction.

Reference Materials:

1. - Russell, S. and Norvig, P. Artificial Intelligence: A Modern Approach. Fourth edition. Prentice Hall. 2015. ISBN-10: 0136042597, ISBN-13: 978-0136042594.
2. Gonzalez, A. J. and Dankel, D. D. The Engineering of Knowledge-based Systems. Prentice Hall, 1993. ISBN-10: 0132769409, ISBN-13: 978-0132769402.
3. Artificial Intelligence – Elaine Rich, Kevin Knight, Durkin, J., Expert Systems: Design and Development. Prentice Hall, New York, NY, 1994. ISBN-10: 0023309709, ISBN-13: 978-0023309700.
4. Puppe, F. Systematic Introduction to Expert Systems: Knowledge Representations and
5. Problem-Solving Support Material and resources
PROLOG programming language software, Internet

2. OBE components of BS (CS) Program

2.1 Vision

The Hazara University seeks to play an inspiring role in imparting high-quality education and research in the fields of sciences, emerging technologies and other disciplines.

2.2 Mission

The mission of the Hazara University is to provide excellent teaching and research environment to produce graduates who distinguish themselves by their professional competence, research, entrepreneurship, humanistic outlook, ethical rectitude, pragmatic approach to problem solving, managerial skills and ability to respond to the challenge of socio-economic development to serve as the vanguard of techno-industrial transformation of the society.

2.3 The Program Educational Objectives (PEOs)/POs of BS (CS) are:

PEO-1: Graduates utilizing their skills and knowledge to solve complex problems in real-world settings.

PEO-2: Graduates practicing in the area of computer science in a socially and ethically responsible way.

PEO-3: Graduates demonstrating lifelong learning skills in computer science and allied disciplines.

PEO-4: Communicate effectively, demonstrate leadership, and work collaboratively in diverse teams/organizations.

2.4 List of BSCS Courses' CLOs, and their mapping to GAs and Course Contents

Distribution of COMMON COURSES for BS (82 Credits) Computing Core

List of Courses Courses Code	Course Title	Credit hours
CS101	Programming Fundamentals	3-1
CS102	Object Oriented Programming	3-1
CS200	Data Structures & Algorithms	3-1
CS201	Discrete Structures	3-0
CS202	Operating Systems	3-1
CS300	Database Systems	3-1
CS301	Software Engineering	3-0
CS302	Computer Networks	3-1
CS402	Information Security	3-0
CS400	Final Year Project-I	0-3
CS401	Final Year Project-II	0-3
Total		39 (27-12)

Course Code: CS101

Course Title: Programming Fundamental

Credit Hours: 4(3+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1	Demonstrate problem-solving skills by developing and implementing algorithms to solve problems	GA-4
2	Derive problem specifications from problem statements	GA-3
3	Develop algorithms using modular design principles to meet stated specifications	GA-4
4	Create code to provide a solution to problem statements ranging from simple to complex	GA-4
5	Test and debug programs and program modules to meet specifications and standards	GA-2
6	Create programs that contain clear and concise program documentation	GA-4
7	Incorporate both basic and advanced control structures appropriately into algorithms	GA-4

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
1	Implement programs that use data types and demonstrate an understanding of numbering systems	GA-2
2	Apply code reading and debugging techniques to analyze, interpret, and describe the purpose of program code, and to identify errors in syntax, logic, style, or good practice	GA-5
3	Demonstrate an understanding of structure design by implementing programs with functions, including parameter passing and value returning	GA-2
4	Implement algorithms using one-dimensional and indexed data structures	GA-4
5	Demonstrate an understanding of array searching and sorting algorithms by desk-checking and/or modifying algorithm implementations	GA-2
6	Design and implement menu-driven programming techniques to branch the program execution from the general to specific sections of the program	GA-4
7	Implement programs by applying different data operations on strings and files	GA-4
8	Apply the principles of structured programming to the design and implementation of algorithms as computer programs	GA-4

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, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations

Course Code: CS102

Course Title: Object Oriented Programming

Credit Hours: 4(3+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Demonstrate fundamental principles and concepts of object-oriented programming. Understanding	GA-2
2.	Apply the concepts of object-oriented programming principles (abstraction, inheritance, and polymorphism.) along with interfaces to solve a real-world problem.	GA-3
3.	Apply event handling model to develop event-driven programs that respond to user events.	GA-3
4.	Apply the concept of exception handling and file-based approaches to develop error proven & to store data for users/programmers.	GA-4

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
1.	Implement a small module utilizing Object-Oriented design	GA-4
2.	Develop a file-based project for a real-world problem in a C++ environment.	GA-5
3.	Develop a exception handling based projects for real world problem using C++ environment.	GA-5

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 Code: CS200

Course Title: Data Structures and Algorithms

Credit Hours: 4 (3+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Elaborate concepts of data, types of data, basic operations on data and logical organizations of data.	GA-2
2.	Elaborate different organizations of data, their types and their relevant advantages and disadvantages.	GA-2
3.	Enabling how to select a data organization for a given set of data keeping in view the required operations on the data.	GA-3
4.	Enabling how to write an algorithm for a given operation.	GA-4
5	Demonstrating the concept of processing time and memory requirements of data and the concepts of time and space complexity of computer programs.	GA-2

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
1.	Understanding of how to convert an algorithm into a program using some specific programming language.	GA-5
2.	Implementing algorithms in C++/Java.	GA-4
3.	Practicing and evaluating the time and space complexity for different programs for the same operation.	GA-3
4.	Implementing and elaborating recursive programs.	GA-2

Course Contents

Abstract data types, complexity analysis, Big Oh notation, 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 tress, balanced trees, graphs, breadth-first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection

Course Code: CS-201

Course Title: Discrete Structures

Credit Hours: 3

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs, and Trees etc.	GA-1
2.	Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	GA-3
3.	Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	GA-3
4.	Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular.	GA-2

Course Contents
Mathematical reasoning, 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 Code: CS202

Course Title: Operating System

Credit Hours: 4(3+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Elaborate concepts and principles of operating systems and identify the core functions of the Operating Systems	GA-2
2.	Analyzing the issues of Process Management including process structure, multiprocessing, synchronization, scheduling and communication.	GA-3
3.	Demonstrating memory management issues including advance techniques of paging, segmentation and virtual memory.	GA-3
4.	Demonstrating the operations of various File Management Algorithms.	GA-3
5.	Discuss the issues related to I/O Sub-systems, Threats and specialized operating systems.	GA-2

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
1.	Operate basic services and functionality of operating systems.	GA-8
2.	Simulating the concepts of process management, memory management and file management.	GA-4
3.	Accessing basic OS commands and OS External Commands using C/C++ coding.	GA-2
4.	Accessing I/O devices using int86() function of C/C++ without OS functions	GA-2

Course Contents
Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading 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 Code: CS-300

Course Title: Database System

Credit Hours: 3

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Explain database concepts and principles.	GA-2
2.	Design conceptual, logical and physical database schemas using different data models	GA-4
3.	Identify functional dependencies and resolve database anomalies by normalizing database tables.	GA-3
4.	Use Structured Query Language (SQL) for database definition and manipulation in any DBMS	GA-5
5.	Describe the principles of transaction management.	GA-2

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 systemsprotection, virtual machines, operating system security

Course Code: CS-301

Course Title: Software Engineering

Credit Hours: 3

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	Describe various software engineering processes and activities	GA-1
2.	Apply the system modeling techniques to model a medium size software system	GA-3
3.	Apply software quality assurance and testing principles to medium size software system	GA-4
4.	Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis	GA-5

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 Code: CS302

Course Title: Computer Networks

Credit Hours: 3(2+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1	Explain the services and functions provided by each layer in the TCP/IP and OSI models.	GA-6
2	Identify various internetworking devices and protocols, and their functions in a network.	GA-1
3	Build Computer Network on various Topologies.	GA-2

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 Code: CS402

Course Title: Information Security

Credit Hours: 3

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1.	The student will develop an understanding of security policies (such as confidentiality, Integrity, and availability), as well as protocols to implement such policies	GA-2
2.	Student learn basics of information security, in both management aspect and technical aspect. Students understand of various types of security incidents and attacks, and learn methods to prevent detect and react incidents and attacks.	GA-5
3.	Students will also learn basics of application of cryptography which are one of the key technologies to implement security functions	GA-4
4.	Student will gain knowledge about securing both clean and corrupted systems, protect personal data, and secure computer networks.	GA-2

Course Contents
Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, key management, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.

Course Code: CSE-400

Course Title: Final Year Project-1 (FYP-1)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	To identify and formulate a computer-based system according to agreed requirements	GA-3
2.	To use and implement latest tools and technologies to meet the requirement of the software industry	GA-5
3.	To apply software engineering theory and practices in the modeling and design of computer-based systems	GA-4

Course Code: CSE-401

Course Title: Final Year Project-2 (FYP-2)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	To select and utilize the knowledge, techniques and skills of their respective discipline to produce a mandatory system	GA-2
2.	To work effectively in a team environment	GA-6
3.	To apply the professional, ethical, legal, and social issues and responsibilities	GA-9
4.	To present effectively to a range of audiences	GA-7

General Education
List of Courses

Code	Course Title	Credit hours
ENG100	English Composition & Comprehension	3
ENG201	Academic Reading & Writing	3
ENG102	Communication & Presentation Skills	3
CS340	Professional Practices	3
CS100	Introduction to Computing	2-1
ISL100	Islamic Studies	3
	Total	17-1

Course Code: ENG100

Course Title: English-1(English Composition & Comprehension)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	The course aims at enhancing students' skill and competence in communicating their ideas in writing and speaking in English language.	GA1
2.	It will primarily focus on four areas of language to help the students achieve proficiency in language use, develop skills in listening comprehension, improve reading efficiency, use the conventions of standard written English with skill and assertion	GA2
3.	The course will able the learners to build-up vocabulary, and clearly and accurately reproduce specific data.	GA 4
4.	It will illustrate the force and effectiveness of simple and direct English.	GA5

Course Contents

Parts of Speech, Figures of Speech, Direct/Indirect Narration, Punctuation, Reading Comprehension, Listening Comprehension, Common Writing Errors, Writing Techniques, Paragraph Writing, Essay Writing, Story-Telling, Letter Writing

Course Code: ENG-300

Course Title: English-3 (Technical & Business Writing)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	The course aims at enhancing students' skill and competence in communicating their ideas in writing and speaking in English language.	GA1
2.	It will primarily focus on four areas of language to help the students achieve proficiency in language use, develop skills in listening comprehension, improve reading efficiency, use the conventions of standard written English with skill and assertion	GA2

Course Contents

Technical writing, overview/ strategies/Do's and Don'ts, Technical vocabulary, Language technicalities, steps to effective writing, Common Writing Errors, Proofreading and editing, memo writing, Letter writing, Email writing, Report writing, Minutes Taking, User Manuals, Presentation Skills, CV and Cover Letters, Interview Skills

Course Code: ENG-200

Course Title: English-2 (Communication & Presentation Skills)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	To enhance students' linguistic command, so they could communicate effectively in diversified socio-cultural situations; create larger stretches of interactive text in speech and writing; and identify and repair any instances of potential communication break-up	GA1
2.	It will focus on students' ability to effectively convey and exchange information in cross-cultural, international, and multinational milieu necessitated by the emergence of global society.	GA2
3.	The course will able the learners to communicate effectively in the target language.	GA 4

Course Contents
Communication Overview, Nonverbal Communication, Paralanguage, Listening, Seven C's of Communication, Comma Splice/Run-ons/Fragments/ Parallelism, Telephone Skills, Business Meetings, Note-taking, Proofreading and Editing, Presentation Skills, Email/ Letter Writing

Course Code: CS241

Course Title: Professional Practices

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to Understand and Apply Ethical Principles in Computing	GA-1
2.	Students will be able to Analyze and Evaluate Organizational Structures and Practices within the Computing Industry	GA-2
3.	Students will be able to apply legal and professional responsibilities in computing	GA-4
4.	Students will be able to use social and professional accountability in the computing profession	GA-3

Course Contents
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 Code: CS-100

Course Title: Introduction to Information & Communication Technologies

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, the students will be able to understand computer systems and software	GA2
2.	To develop proficiency in Office Productivity Tools (MS Word, MS Excel, and MS PowerPoint)	GA3
3.	To understand the concepts of operating systems, number systems, memory classification, and database management systems (DBMS), and security measures	GA4
4	To get familiarity with Internet Technologies and Programming Fundamentals	GA5

Course Contents

Introduction to computer, Registers, Cache Memory etc.), Parts of Computer System (Input devices, Output devices etc.), Application Software Vs. System Software, System Software, its importance and its types (Utilities, Device Drivers etc.), MS Word with basic commands, MS Excel with basic features including financial, logical and text functions, Visualizing data in excel (column charts, bar charts, pie charts), MS PowerPoint, Introduction to Operating System, Introduction to Number System and its types, Memory Classification (Primary and Secondary Memories), Memory Types (e.g. Hard Disk, Optical Disk, Flash Disk etc.), RAM and ROM, Introduction to Database and DBMS, Security, Encryption/Decryption, Privacy, Computer Viruses and Worms, Social Media Platforms and its pro and cons, Data Structure, Algorithms, Pseudocodes, Phases of Software Development, Data Communication Model (Sender, Receiver, Transmission Medium), Network Topologies, Internet, World Wide Web, Browser and URL, Search Engines, Internet Services Provider, Email Creation and Uses, HTML and Basic Tags, Making Simple HTML Page, Computer Programming Languages and its types (Machine Language, Low Level Language, High Level Languages), Notepad, Integrated Development Environment (e.g. Visual Studio, Eclipse, Dev C++) its Importance and Functions, Artificial Intelligence, Applications of AI (e.g. Robotics, NLP, expert systems), Introduction to ERP (Enterprise Resource Planning) Software, Student Orientation on CMS (Campus Management System)

Course Code: ISL100

Course Title: Islamic Studies

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Capability to enhance the knowledge of Islam.	GA-1
2.	Capability to understand the basic concept of Islam and its sources.	GA-2
3.	Capability to understand ethical responsibility and Religious life.	GA-9
4.	The ability to understand Moral, economic & practical issues in Islamic perspective.	GA-8

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

Mathematics and Science Foundation Courses

List of Courses

Course Code	Course Title	Credit Hours
MTH101	Mathematics(Calculus)	3-0
STAT202	Probability & Statistics	3-0
MTH210	Linear Algebra	3-0
PHY240	Applied Physics	3-0
	Total	12-0

Course Code: MTH100

Course Title: Mathematics(Calculus)

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	At the end of the course the students will be able to understand the concepts of limits and continuity	GA-1
2.	To develop a thorough understanding of differential calculus by grasping the concept and idea of differentiation	GA-3
3.	To apply the principles of differentiation to solve real-world problems and explore diverse applications	GA-2
4.	To attain proficiency in integral calculus by understanding the concept of integration, evaluating indefinite integrals, applying techniques of integration	GA-4

Course Contents
Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of finding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential calculus; Concept and idea of differentiation, Geometrical and Physical meaning of derivatives, Rules of differentiation, Techniques of differentiation, Rates of change, Tangents and Normals lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation; Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity, Integral calculus; Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve, Analytical Geometry; Straight lines in R^3 , Equations for planes.

Course Code: CS-124

Course Title: Probability and Statistics

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire the basic knowledge of the discipline of Statistics and applied in field of AI.	GA-2
2.	Evaluate and interpret basic descriptive statistics. Display, Interpret data graphs	GA-4
3.	Acquire the basic knowledge of statistical estimators, probability and probability distribution functions and use to developed statistical software	GA-5
4.	Understand the concepts of basic techniques of measuring the uncertainty problem and solve the real life problems,	GA-10

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 Code: MTH210
Course Title: Linear Algebra
Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to explain and apply the fundamental concepts of linear algebra	GA-1
2.	They will be able to understand the structure and properties of vector spaces	GA-2
3.	They will be able to master orthogonal transformations and the concept of inner product spaces	GA-3
4.	Students will develop the ability to calculate eigenvalues and eigenvectors, understand their significance in linear transformations	GA-4

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 form

Course Code: CS- 140

Course Title: Applied Physics

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Gain a comprehensive understanding of electric forces and fields	GA-2
2.	Master the principles of Gauss' Law and its applications in determining electric fields	GA-3
3.	Acquire a solid understanding of electric current, current density, resistance, resistivity, and conductivity, along with Ohm's law and its applications in electric circuits	GA-4

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, equipotential 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

**University Elective
List of Courses**

(Select any 4, Not limited to the list below, University may add more courses)

Course Code	Course Title	Credit hours
SOC100	Sociology	3-0
PSY100	Psychology	3-0
MGT100	Principles of Management	3-0
ECON100	Basic Economics	3-0
	Total (ANY Four from above)	12-0

Course Code: SOC100

Course Title: Sociology

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, the students will develop reflexive capacity by fostering critical self-awareness, encouraging them to examine their assumptions, values, and biases, and to reflect on how these influence their perceptions, behaviors, and interactions with others	GA-1
2.	Cultivate students' ability to critically analyze and innovate by encouraging them to break with common sense assumptions, challenge prevailing paradigms, and explore alternative perspectives to address complex problems and generate creative solutions	GA-2
3.	To Understanding Social Phenomena	GA-3
4.	To Development of Writing and Reading Skills	GA-4
5.	To engage in Group Work and Oral Presentation Skills	GA-5
6.	To develop and promote Inter-relational Competences	GA-6

Course Contents
Sociological Perspective, Structural Functionalism, Social Conflict, Symbolic Interactionism, Social Institution, Social Control, Social Process, Socialization, Culture, Society, Social interaction.

Course Code: PSY-100
Course Title: Psychology
Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, the students will be able to understand the fundamental theories and concepts that underpin various psychological perspectives, including behaviorism, psychoanalysis, cognitive psychology, and humanistic psychology	GA1
2.	To analyze the key principles of research methods employed in psychology, such as experimental design, surveys, case studies, and observational techniques	GA4
3.	Enable students to implement the Psychological concepts in the Human Computer Interaction (HCI) to design usable things.	GA8

Course Contents
understanding psychology, research methods, biological basis of behavior, cognition, language, intelligence, creativity, sensation, perception, learning, memory, motivation, emotions

Course Code: MGT-100

Course Title: Principles of Management

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to specify how the managerial tasks of planning, organizing, and controlling can be executed in a variety of circumstances.	GA-1
2.	They will be able assess global situation, including opportunities and threats that will impact management of an organization.	GA-3
3.	The course will help them to integrate management principles into management practices.	GA-2
4.	They will be able to determine the most effective action to take in specific situations and evaluate approaches to addressing issues of diversity.	GA-4

Course Contents
Basic concept, Organization, Organizational type, Component of organization, Definition and process of Mgt. Other concept of management. SWOT analysis of organization, Foundation of basic element in planning, Decision making, Definition decision / nature of decision, Strategic management, Organizational structure, Human resources management, Leadership, team work and group behavior, staffing, Controlling, Definition of controlling, Nature of controlling Importance of controlling, Controlling process

Course Code: ECON-100

Course Title: Basic Economics

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand consumer, Producer behavior, macroeconomic indicators issues, Environmental economics aspects of a country.	GA-1
2.	Apply graphical analysis for a variety of economic situations	GA-4
3.	Calculate and interpret elasticities.	GA-3
4.	Define and derive short-run and long-run production costs	GA-5
5.	Explain various market structures	GA-7

Course Contents
Introduction to economics school of thoughts; Microeconomics, macroeconomics, Scarcity, Consumer theory; Demand and Law of demand, schedule, graph, limitations; Utility, Law of diminishing marginal Utility, graph, limitations; Supply, law of supply, schedule, graph, determinants of supply; Equilibrium point. Surplus and shortage; Elasticity, types of elasticity; Indifference curve, properties of Indifference curve; Budget line, Marginal rate of substitution; Utility maximization through IC and budget line; Producer Behavior, objective of the producer; Cost, types of cost; Revenue , types of Revenue , Profit; Law of return to scale; Market, Types of markets; Markets based on economic competition (Introductory treatment); Basic Macroeconomics concepts; GDP, GNP , NNP , National Income, PC; Circular flow of national income; Real GDP vs Nominal GDP; Inflation , types of inflation and its causes; Consumer price index and its relationship with inflation; Economic problems of Pakistan; Interest rate, and its types; Unemployment and its types; Economic growth vs Economic development; Monetary Policy of Pakistan; Fiscal policy; Introduction to taxation; Sustainable Development Goals

Domain Courses for BS (COMPUTER SCIENCE)

Computer Science CORE (Compulsory)

List of Courses

Course Code	Course Title	Credit hours
CS210	Comp. Organization & Assembly Language	3-1
CS211	Digital Logic Design	3-1
CS212	Theory of Automata	3-0
CS310	Compiler Construction	3-0
CS311	Design & Analysis of Algorithms	3-0
CS312	Artificial Intelligence	3-1
CS410	Parallel & Distributed Computing	3-0
	Total	24 (21-3)

Course Code: CS- 210

Course Title: Computer Organization and Assembly Language

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire the basic knowledge of computer organization, computer architecture and assembly language	GA-1
2.	Understand the concepts of basic computer organization, architecture, and assembly language techniques	GA-2
3.	Solve the problems related to computer organization and assembly language	GA-3

Course Contents
Introduction to computer systems: Information is bits + context, programs are translated by other programs into different forms, it pays to understand how compilation systems work, processors read and interpret instructions stored in memory, caches matter, storage devices form a hierarchy, the operating system manages the hardware, systems communicate with other systems using networks; Representing and manipulating information: information storage, integer representations, integer arithmetic, floating point; Machine-level representation of programs: a historical perspective, program encodings, data formats, accessing information, arithmetic and logical operations, control, procedures, array allocation and access, heterogeneous data structures, putting it together: understanding pointers, life in the real world: using the gdb debugger, outof-bounds memory references and buffer overflow, x86-64: extending ia32 to 64 bits, machine-level representations of floating-point programs; Processor architecture: the Y86 instruction set architecture, logic design and the Hardware Control Language (HCL), sequential Y86 implementations, general principles of pipelining, pipelined Y86 implementations

Course Code: CS352

Course Title: Digital Logic Design

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits	GA-1
2.	Demonstrate the skills to design and analyze both combinational and sequential circuit using a variety of techniques	GA-2
3.	Apply the acquired knowledge to simulate and implement small-scale digital circuits	GA-3
4.	Understand the relationship between abstract logic characterizations and practical electrical implementations.	GA-4

Course Contents
Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey 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 Code: CS212

Course Title: Theory of Automata

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain different concepts in automata theory and formal languages such as computational models, automata, regular expressions, Grammar etc.	GA-2
2.	Identify the language description and choose appropriate computational model to design it	GA-3
3.	Design and develop formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.	GA-4
4.	Transform between equivalent NFAs, DFAs and Res	GA-4
5.	Apply software tools (such as JFLAP) to implement computational models.	GA-5

Course Contents
Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: Context Free Grammars , Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, Turing Machines Theory: Turing machines

Course Code: CS307

Course Title: Compiler Construction

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1	Understand the basic techniques used in compiler construction such as lexical analysis, top-down, bottom-up parsing, context-sensitive analysis, and intermediate code generation	GA-2
2	Understand the basic data structures used in compiler construction such as abstract syntax trees, symbol tables, three-address code, and stack machines	GA-3
3	Design and implement a compiler using a software engineering approach	GA4
4	Use generators (e.g. Lex and Yacc)	GA5

Course Contents
Introduction to interpreter and compiler. Compiler techniques and methodology; Organization of compilers; Lexical and syntax analysis; Parsing techniques. Types of parsers, top-down parsing, bottom-up parsing, Type checking, Semantic analyzer, Object code generation and optimization, detection and recovery from errors

Course Code: CSC201

Course Title: Design and Analysis of Algorithms

Credit Hours: 3(3)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1	Explain study of the basic notions of the design of algorithms and the underlying data structures	GA-1
2	Argue the correctness of algorithms using inductive proofs and invariants	GA-3
3	Find the measures of complexity and Efficiency of algorithm	GA-2
4	Analyze worst-case running times of algorithms using asymptotic analysis	GA-3
5	Describe the divide-and-conquer paradigm. Propose divide-and-conquer algorithms. Derive and solve recurrences describing the performance of divide-and-conquer algorithms.	GA-4
6	Describe the dynamic-programming paradigm. Propose dynamic-programming algorithms, and analyze them	GA-2
7	Propose greedy algorithms, and analyze them	GA-3
8	Explain the major graph algorithms and their analyses. Describe the graph application in CS domain	GA-3
9	Compare between different data structures. Pick an appropriate data structure for a design situation	GA-2
10	Explain what an approximation algorithm is, and the benefit of using approximation algorithms. Analyze the approximation factor of an algorithm	GA-3

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;

Course Code: CS-483

Course Title: Artificial Intelligence

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand key components in the field of artificial intelligence	GA-1
2.	Implement classical artificial intelligence techniques	GA-4
3.	Analyze artificial intelligence techniques for practical problem solving	GA-3

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Develop experience in using image processing software and programming languages (Python) to implement algorithms and solve complex image processing tasks	GA-5

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, Alpha beta 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 Code: CS410

Course Title: Parallel & Distributed Computing

Credit Hours: 3(2+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain the basic concepts of parallel and distributed computing.	GA-2
2.	Analyze the application and performance of parallel algorithms.	GA-3
3.	Demonstrate parallel programming algorithms using GPU	GA-3
4.	Apply the concept of socket programming and thread programming to evaluate the parallel and distributed systems practically.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Implement parallel programming algorithms using GPU.	GA-4
2.	Develop an application using concepts of distributed and parallel computing in a team environment.	GA-5

Course Contents
Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD, multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE).

Computer Science SUPPORTING courses

(Any 3 from following list)

List of Courses

Course Code	Course Title	Credit hours
MTH202	Differential Equations	3-0
CS330	Graph Theory	3-0
	Total (Any three of the above)	6-0

Course Code: MTH202

Course Title: Differential Equations

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Identify, analyze and subsequently solve physical situations whose behavior can be described by ordinary differential equations.	GA-1
2.	Determine solutions to first order separable differential equations	GA-3
3.	Determine solutions to first order linear differential equations.	GA-2
4.	Determine solutions to first order exact differential equations and second order linear homogeneous and non-homogeneous differential equations with constant coefficients	GA-4

Course Contents
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. Ordinary Linear Differential Equations; Homogeneous Linear Equations of the Second Order, Homogeneous Second-Order Equations with Constant Coefficients, General Solution, Real Roots, Complex Roots, Double Root of the Characteristic Equation, Differential Operators, Cauchy Equation, Homogeneous Linear Equations of Arbitrary Order, Homogeneous Linear Equations of Arbitrary Order with Constant Coefficients, Non- homogeneous Linear Equations. Modelling of Electrical Circuits. Systems of Differential Equations. Series Solutions of Differential Equations. Partial Differential Equations: Method of Separation of variables, wave, Heat & Laplace equations and their solutions by Fourier series method.

Course Code: CS307

Course Title: Graph Theory

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1	Fundamental concepts of Graph Theory	GA-1
2	Provide knowledge for application of Graph Theory in subsequent courses in the design and analysis of algorithms, computability theory, software engineering and computer systems.	GA-2

Course Contents
Introduction to Graph Theory, Basic definitions, computer representations and properties of Graph, Data structure for representing Graphs, Fundamental theorem of Graph Theory, Isomorphic and Special Graphs, Properties of Trees and Forests, Binary tree, Balanced binary tree, Directed and Undirected rooted tree, Minimum Spanning Tree algorithms and implementation, Path and Distance in graphs, Shortest path algorithms and implementation, Cycle and distance in weighted graph and digraphs, Distance algorithms and implementation, Eulerian graphs and Hamiltonians graphs with applications, Flow networks, Max-flow Min-cut Theorem, Graph coloring, Edge coloring, Planar graphs, Four color theorem, Deadlock of computer system, Matching Algorithms, Dominance & Ramsey theory.

Computer Science ELECTIVE courses

List of Courses

(Choose any Five courses, Not limited to the list below, University may add more courses)

Course Code	Course Title	Credit hours
SE313	Web Engineering	3-0
CS423	Cloud Computing	3-0
CS421	Mobile Application Development	3-0
CS322	Digital Image Processing	3-1
SE410	Software Project Management	3-0
	Total(Any Five)	15

Course Code: SE313

Course Title: Web Engineering

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Discuss how web standards impact software development.	GA-2
2.	Describe the constraints that the web puts on developers.	GA-3
3.	Design and Implement a simple web application.	GA-4
4.	Review an existing web application against a current web standard.	GA-5

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 Code: CS423

Course Title: Cloud Computing

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understanding basic concepts of distributed systems	GA-1
2.	Understanding of cloud computing technologies	GA-2
3.	Understanding of Virtualization and its various flavors	GA-4
4.	Ability to address large scale data processing challenges	GA-3

Course Contents
Introduction to Cloud Computing, History and Background of Cloud Computing, Basics of Computers, Basics of Data Communication Basics of Computer Networking Advanced Topics of Computer Networks Virtualization Essential Characteristics of Cloud Computing Benefits of Cloud Computing Risks and Challenges of Cloud Computing Roles and Boundaries of Cloud Computing Cloud Service Models Data Storage in Clouds Miscellaneous Services of Cloud Computing Cloud Deployment Models Service Oriented Architecture Cloud Security Threats Trust Issues in Cloud Mechanisms Related to Cloud Infrastructure Service Agreements Cloud Hosting Data Center Design Cloud Architecture Specialized Cloud Mechanisms Cloud Management Fundamental Cloud Architectures Advanced Cloud Architectures Cloud Federation Cloud Delivery/Service Models' Perspectives Inter-Cloud Resource Management Cloud Cost Metrics and Pricing Models Cloud Service Quality Metrics Cloud Simulator Computer Security Basics Network Security Basics Cloud Security Mechanisms Privacy Issues of Cloud Computing Security Issues of Cloud Computing Trust Issues of Cloud Computing Open Issues in Cloud Disaster Recovery in Cloud Computing Migrating to the Cloud Cloud Application Scalability and Resource Scheduling Mobile Cloud Computing

Course Code: CS421

Course Title: Mobile Application Development

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Discuss different architectures & framework for Mobile Application development	GA-2
2.	Develop mobile applications using current software development environments.	GA-4
3.	Compare the different performance tradeoffs in mobile application development	GA-3
4.	Implement a small module using Android programming.	GA-6

Course Contents
Mobiles Application Development Platform; HTML5 for Mobiles; Android OS: Architecture, Framework and Application Development; iOS: Architecture, Framework; Application Development with Windows Mobile; Eclipse; Fragments; 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; Getting Feedback; Sending Email; Displaying Maps; Consuming Web Services Using HTTP; Web Services: Accessing and Creating; Threading; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages; Challenges with Mobility and Wireless Communication; Location-aware Applications; Performance/Power Tradeoffs; Mobile Platform Constraints; Emerging Technologies.

Course Code: CS322

Course Title: Digital Image Processing

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understand the basics of digital image processing, applications in general, working inside the digital camera, sampling and quantization, image representation, etc.	GA-1
2.	Implement image enhancement, image segmentation, image transformations, spatial and frequency domain processing, filtering, convolution, image registration, feature detection	GA-2
3.	Evaluate the performance of different image processing algorithms	GA-4
4.	Apply advanced topics in digital image processing, such as feature extraction, pattern recognition	GA-3

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Develop experience in using image processing software and programming languages (such as MATLAB, Python with OpenCV, or other relevant tools libraries like OpenCV and PIL) to implement algorithms and solve complex image processing tasks	GA-5

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

Course Code: CSE-410

Course Title: Software Project Management

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain principles of the project lifecycle and how to identify opportunities to work with learners on relevant and appropriate project scenarios to share this understanding	GA-1
2.	Critically evaluate and discuss the issues around project management and its application in the real world with course participants and learners	GA-2
3.	Choose project management techniques for IT projects to initiate, plan, execute and evaluate a project and work in teams to create a project plan for a project scenario that includes key tasks, critical path, dependencies and a realistic timeline.	GA-3
4.	Present strategies for gaining confidence in managing projects through simple project planning examples.	GA-4

Course Contents
Introduction to Software Project Management, Project Management concepts, Project Management Tools, PMI's Knowledge areas, PMI Framework, PMI Process Groups. Understanding Organizations. Project Planning, Project Evaluation, Selection of an Appropriate Approach in Project, Software Effort Estimation, Activity Planning, Risk Management, Evaluating the Risks to the Schedule, Risk Control, Configuration Management and Maintenance, Environment for Configuration Control, Resource Allocation, Monitoring & Control, Review and Evaluation, Challenges of Outsourcing in Project Management

3. OBE components of BS (SE) Program

3.1 University Vision

Hazara University intends to be a standard university providing affordable quality educational opportunities for students to develop scientific, socio-culture, economic and political leadership, through learner-centred teaching and research, while strengthening their identity at Regional, National and International level.

3.2 Department of Computer Science and IT: Mission

The mission of the Department of CS&IT at Hazara University is to provide affordable and excellent teaching and research environment to produce graduates who are distinguished from others because of their core competency in the discipline and associated attributes. These include professional competence, research, entrepreneurship, humanistic outlook, ethical rectitude, pragmatic approach to problem solving, managerial skills and ability to respond to the challenge of socio-economic development.

3.3 The Program Educational Objectives (PEOs)/POs of BS (SE) are:

PEO-1: Graduates utilize their diverse technical skills and in-depth software engineering & development knowledge to build complex software systems in real-world settings.

PEO-2: Graduates act responsibly and ethically in their profession and as informed citizens, and possibly make a socio-economic impact.

PEO-3: Graduates demonstrate lifelong learning skills in Software Engineering and allied disciplines.

PEO-4: Communicate effectively, demonstrate leadership, and work collaboratively in diverse teams/organizations.

3.4 List of BSSE Courses' CLOs, and their mapping to GAs and Course Contents

Sr. No	Code	Course Title	Credits hours	Distribution
1	CS100	Programming Fundamentals	3+1	Computing Core
2	CS102	Object Oriented Programming	3+1	
3	CS200	Data Structure and Algorithms	3+1	
4	CS201	Discrete Structures	3	
5	CS202	Operating System	3+1	
6	SE300	Database Systems	3+1	
7	SE301	Software Engineering	3	
8	CS302	Computer Networks	2+1	
9	CS402	Information Security	3	
10	CS400	FPY-I CS400	3	
11	CS401	FPY-II CS401	3	
12	ENG100	English 1	3	General Education
13	ENG200	English 2	3	
14	ENG300	English 3	3	
15	CS340	Professional Practices	3	
16	CS100	Introduction to computing	3	
17	ISL100	Islamic studies	3	
18	STAT202	Probability & Statistics	3	Mathematics and Science Foundation Course
19	MTH210	Linear Algebra	3	
20	SOC100	Sociology	3	University Elective
21	MGT100	Principles of Management	3	
22	ECON100	Basic Economics	3	
23	SE210	Human computer Interaction	3	Software Engineering Core
24	SE211	Software Requirements Engineering	3	
25	SE212	Software Design & Architecture	2+1	
26	SE310	Software Construction & Development	2+1	
27	SE311	Software Quality Engineering	3	
28	SE212	Software Re-Engineering	3	
29	SE313	Web Engineering	3	
30	SE410	Software Project Management	3	
31	SE330	Formal Methods in Software Engineering	3	Supporting Course
32	SE331	Simulation and Modelling	3	
33	CS423	Cloud Computing	3	Elective Courses
34	CS422	Internet of things	3	
35	CS421	Mobile App Development	3	
36	SE422	Software Metrics	3	
37	SE424	Failure Analysis & Recovery	3	
38	SE423	Software Testing	3	

Distribution of COMMON COURSES for BS Computing Core

Course-Code	Course Title	Credit Hr	Category
CS100	Programming Fundamentals	3+1	Computing Core
CS102	Object Oriented Programming	3+1	Computing Core
CS200	Data Structure and Algorithms	3+1	Computing Core
CS201	Discrete Structures	3	Computing Core
CS202	Operating System	3+1	Computing Core
SE300	Database Systems	3+1	Computing Core
SE301	Software Engineering	3	Computing Core
CS302	Computer Networks	2+1	Computing Core
CS402	Information Security	3	Computing Core
CS400	FPY-I CS400	3	Computing Core
CS401	FPY-II CS401	3	Computing Core

Course Code: CS101

Course Title: Programming Fundamentals

Instructor: Dr. Hizbullah Khattak

Credit Hours: 4(3+1)

CLO #	Course Learning Outcome (CLO) of Theory	Graduate Attribute
1	Understand basic problem-solving steps and logic constructs	GA-2
2	Apply basic programing concepts	GA-3
3	Design and implement algorithms to solve real world problems.	GA-4

CLO #	Course Learning Outcome (CLO) of Lab	Graduate Attribute
1	Implement programs that use data types and demonstrate an understanding of numbering systems	GA-2
2	Apply code reading and debugging techniques to analyze, interpret, and describe the purpose of program code, and to identify errors in syntax, logic, style, or good practice	GA-5
3	Implement algorithms using one-dimensional and indexed data structures	GA-4
4	Demonstrate an understanding of array searching and sorting algorithms by desk-checking and/or modifying algorithm implementations	GA-2
5	Apply the principles of structured programming to the design and implementation of algorithms as computer programs	GA-4

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, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations

Course Code: CS102

Course Title: Object Oriented Programming

Instructor: Asif Umer

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand principles of object-oriented paradigm.	GA-2
2.	Identify the objects & their relationships to build object-oriented solution.	GA-3
3.	Model a solution for a given problem using object-oriented principles	GA-3
4.	Apply the concept of exception handling and file-based approaches to develop error proven & to store data for users/programmers.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Implementing OOP concepts and principles in C++	GA-4
2.	Develop a client server based small project in C++.	GA-5
3.	File handling based C++ programming to store the data permanently and retrieve it.	GA-5

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 Code: CS200

Course Title: Data Structures and Algorithms

Instructor: Ghulam Mustafa Assad

Credit Hours: 4 (3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Elaborate concepts of data, types of data, basic operations on data and logical organizations of data.	GA-2
2.	Elaborate different organizations of data, their types and their relevant advantages and disadvantages.	GA-2
3.	Enabling how to select a data organization for a given set of data keeping in view the required operations on the data.	GA-3
4.	Enabling how to write an algorithm for a given operation.	GA-4

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	Understanding of how to convert an algorithm into a program using some specific programming language.	GA-5
2.	Implementing algorithms in C++/Java.	GA-4
3.	Practicing and evaluating the time and space complexity for different programs for the same operation.	GA-3
4.	Implementing and elaborating recursive programs.	GA-2

Course Code: CS201

Course Title: Discrete Structures

Instructor: Ms Farzana Shah

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs, and Trees etc.	GA-2
2.	Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	GA-2
3.	Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	GA-3
4.	Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular.	GA-4

Course Contents
Mathematical reasoning, 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 Code: CS202

Course Title: Operating System

Instructor: Miraj Gul

Credit Hours: 4(3+1)

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Elaborate concepts and principles of operating systems and identify the core functions of the Operating Systems	GA-2
2.	Analyzing the issues of Process Management including process structure, multiprocessing, synchronization, scheduling and communication.	GA-3
3.	Evaluate memory management and File Management Algos	GA-3
4.	Discuss the issues related to I/O Sub-systems, Threats and specialized operating systems.	GA-2

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
	Operate basic services and functionality of operating systems.	GA-8
2.	Simulating the concepts of process management, memory management and file management.	GA-4
3.	Accessing basic OS commands and OS External Commands using C/C++ coding.	GA-2
4.	Accessing I/O devices using int86() function of C/C++ without OS functions	GA-2

Course Contents
Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading 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 Code: SE300

Course Title: Database Systems

Instructor: Mr.Hashim Khan

Credit Hours: 4(3+1)

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate Attributes
1.	Explain fundamental database concepts.	GA-2
2.	Design conceptual, logical, and physical database schemas using different data models.	GA-4
3.	Identify functional dependencies and resolve database anomalies by normalizing database tables.	GA-3
4.	Use Structured Query Language (SQL) for database definition and manipulation in any DBMS	GA-5

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate Attributes
1.	Oracle installation configuration and features	GA-5
2.	Design a logical database and perform normalization	GA-3
3.	Execute different categories of SQL queries	GA-4

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 Code: SE301

Course Title: Software Engineering

Instructor: Romana Saleem Khan

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	CLO-1 Explain the concept of software engineering along with its processes and deliverables.	GA-1
2.	CLO-2 Identify functional and non-functional requirements for a medium sized software system.	GA-3
3.	CLO-3 Construct appropriate design models for the structure and behavior of a medium sized software system.	GA-4
4.	CLO-4 Apply software testing and quality assurance techniques to medium sized software.	GA-3
5.	CLO-5 Demonstrate software project management skills and maintenance process.	GA-2

Course Contents
Software Engineering: Overview, and Process Models. Requirement Engineering: Concepts, Elicitation, Analysis, Specification, Modeling and Validation. 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 Title: Computer Networks

Instructor: Dr. Hizbullah Khattak

Credit Hours: 3(2+1)

S. No	Course Learning Outcomes (CLO's of Theory)	Graduate Attribute
1	Explain the services and functions provided by each layer in the TCP/IP and OSI models.	GA-6
2	Identify various internetworking devices and protocols, and their functions in a network.	GA-1
3	Analyze working and performance of key technologies, algorithms and protocols.	GA-3
4	Build Computer Network on various Topologies.	GA-2

S. No	Course Learning Outcomes (CLO's of LAB)	Graduate Attribute
1	Familiarization with networking components and devices (LAN adapter, Hub, Switches, Routers etc.) along with Transmission media and tools (Co-axial cable, UTP cable, Crimping tool, Connectors etc.)	GA-1
2	Preparing the UTP cable for cross and direct connection using crimping tool.	GA-5
3	Configuration of TCP/IP protocols (in Window/LINUX) and TELNET protocols (on router for remote access)	GA-4
4	Build Computer Network on various Topologies.	GA-2

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 Code: CS402

Course Title: Information Security

Instructor: Dr. Noor ul Amin & Muneeba

Credit Hours: 3

Course Contents		
Abstract data types, complexity analysis, Big Oh notation, 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 tress, balanced trees, graphs, breadth-first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection		
S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	The student will develop an understanding of security policies (such as confidentiality, Integrity, and availability), as well as protocols to implement such policies	GA-2
2.	Student learn basics of information security, in both management aspect and technical aspect. Students understand of various types of security incidents and attacks, and learn methods to prevent detect and react incidents and attacks.	GA-5
3.	Students will also learn basics of application of cryptography which are one of the key technologies to implement security functions	GA-4
4.	Student will gain knowledge about securing both clean and corrupted systems, protect personal data, and secure computer networks.	GA-2

Course Contents
Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, key management, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.

FYP-I (CS400)

Course Name	Final Year Project-1
Course Code	CS400
Credit Hours	3 (0+3)
Semester	Spring 2024
Pre-requisites:	Nil

Course Introduction:

The Final Year Project (FYP) is a mandatory prerequisite for award of degree in BS (CS), BS (SE) and BS (AI) programs.

Course Objectives:

- To identify and formulate a computer-based system according to agreed requirements.
- To use and implement latest tools and technologies to meet the requirement of the software industry.
- To apply software engineering theory and practices in the modelling and design of computer-based systems.
- To select and utilize the knowledge, techniques and skills of their respective discipline to produce a mandatory system.
- To work effectively in a team environment.
- To apply the professional, ethical, legal, and social issues and responsibilities.
- To present effectively to a range of audiences.

Course Learning Outcomes (CLO's):

Upon successful completion of the course the student will be able to:

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	To identify and formulate a computer-based system according to agreed requirements.	GA-3
2.	To use and implement latest tools and technologies to meet the requirement of the software industry.	GA-5
3.	To apply software engineering theory and practices in the modelling and design of computer-based systems.	GA-4

FYP-II (CS401)

Course Name	Final Year Project-II
Course Code	CS401
Credit Hours	3 (0+3)
Semester	Spring 2024
Pre-requisites:	Nil

Course Introduction:

The Final Year Project (FYP) is a mandatory prerequisite for award of degree in BS (CS), BS (SE) and BS (AI) programs.

Course Objectives:

- To identify and formulate a computer-based system according to agreed requirements.
- To use and implement latest tools and technologies to meet the requirement of the software industry.
- To apply software engineering theory and practices in the modelling and design of computer-based systems.
- To select and utilize the knowledge, techniques and skills of their respective discipline to produce a mandatory system.
- To work effectively in a team environment.
- To apply the professional, ethical, legal, and social issues and responsibilities.
- To present effectively to a range of audiences.

Course Learning Outcomes (CLO's):

Upon successful completion of the course the student will be able to:

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	To select and utilize the knowledge, techniques, and skills of their respective discipline to produce a mandatory system.	GA-2
2.	To work effectively in a team environment.	GA-6
3.	To apply the professional, ethical, legal, and social issues and responsibilities.	GA-9
4.	To present effectively to a range of audiences.	GA-7

General Education

Course-Code	Course Title	Credit Hr.	Category
ENG100	English 1	3	General Education
ENG200	English 2	3	General Education
ENG300	English 3	3	General Education
CS340	Professional Practices	3	General Education
CS100	Introduction to computing	3	General Education
ISL100	Islamic studies	3	General Education

Course Code: ENG100

Course Title: English-1(English Composition & Comprehension)

Instructor: Mr. Ehtisham

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Master Written Communication Skills	GA-1
2.	Identify and Correct Sentence Errors	GA-2
3.	Enhance Oral Communication and Presentation Skills	GA-3

Course Contents
Paragraph and Essay Writing, Descriptive Essays; Sentence Errors, Persuasive Writing; How to give presentations, Sentence Errors; Oral Presentations, Comparison and Contrast Essays, Dialogue Writing, Short Story Writing, Review Writing, Narrative Essays, Letter Writing

Course Code: ENG-200

Course Title: English-2 (Communication & Presentation Skills)

Instructor: Nuzhat Sultana

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Develop and Apply Advanced Writing Skills	GA-1
2.	Enhance Reading, Listening, and Note-Taking Skills:	GA-2
3.	Excel in Oral Communication and Presentation Techniques	GA-3

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 Code: ENG-300

Course Title: English-3 (Technical & Business Writing)

Instructor: Saira Gul

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to demonstrate proficiency in Technical and Business Communication	GA-1
2.	Apply Best Practices in Document Design and Presentation	GA-2
3.	Engage in Strategic Business Writing and Planning	GA-3

Course Contents
Writing Technical Reports, fundamentals of creating detailed and clear technical reports, structuring and presenting complex information in an accessible manner, focusing on clarity, precision, and the appropriate use of technical terminology, conveying technical information effectively to both technical and non-technical audiences, Business email and correspondence, Proposal writing, creating user manuals and instruction guides, Developing business plans and executive summaries

Course Code: CS340

Course Title: Professional Practices

Instructor: Awais khan

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to Understand and Apply Ethical Principles in Computing	GA-9
2.	Students will be able to Analyze and Evaluate Organizational Structures and Practices within the Computing Industry	GA-8
3.	Students will be able to apply legal and professional responsibilities in computing	GA-8
4.	Students will be able to use social and professional accountability in the computing profession	GA-10

Course Contents
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 Code: CS-100

Course Title: Introduction to Computing

Instructor: Mr. Hashim Khan

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand the fundamental concepts of ICT, including hardware, software, and networks, and their role in society	GA-1
2.	Demonstrate basic knowledge of computer systems, including operating systems and application software	GA-2
3.	Understand and apply principles of digital communication, including the Internet and wireless technologies. Develop a basic website using HTML and CSS, understanding the principles of web design.	GA-3
4.	Explain the importance of data privacy and security in managing information and data. Evaluate the impact of social media and collaboration tools on communication and teamwork.	GA-3
5	Identify emerging technologies like cloud computing, IoT, and AI, and discuss their potential implications. Analyze ethical, legal, and social issues in ICT, including digital ethics, privacy, and accessibility.	GA-4

Course Contents
Introduction to ICT, Definition and history, Overview of components: hardware, software, and networks, role of ICT in society and industries, computer hardware: input, processing, output, and storage devices, basics of computer software: system software and application software, operating systems and user interfaces, principles of digital communication, networking: LAN, WAN, Internet, and intranets, wireless communication and mobile technologies, web technologies, Internet: how it works, its history, and its structure, introduction to web browsers, search engines, and websites, web design and development (HTML, CSS), databases and data management systems, data privacy and security, social media and collaboration tools, overview of social media platforms and their impact, digital citizenship and online etiquette, emerging technologies, Introduction to cloud computing, IoT (Internet of Things), AI and machine learning basics, ethical, legal, and social issues in ICT, digital ethics and intellectual property rights, privacy, security, and cybercrime

Course Code: ISL100

Course Title: Islamic Studies

Instructor: Mr. Amir Farooq

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate Attributes
1.	Appreciate the fundamental concepts of Quran, Ahadees and Sunnah and compare modern day living with them	GA-1
2.	Have an understanding about Islamic Ethics (laws, culture, civilization and contemporary issues.	GA-8
3.	Have an in-depth understanding about Islamic Architecture.	GA-9

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.

Mathematics & Science Foundation Courses

Course-Code	Course Title	Credit Hr.	Category
STAT202	Probability & Statistics	3	Mathematics & Science Foundation
MTH210	Linear Algebra	3	Mathematics & Science Foundation

Course Code: STAT202

Course Title: Probability and Statistics

Instructor: Mr. M. Waseem

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Acquire the basic knowledge of the discipline of Statistics and applied in field of AI.	GA-1
2.	Evaluate and interpret basic descriptive statistics. Display, Interpret data graphs	GA-4
3.	Acquire the basic knowledge of statistical estimators, probability and probability distribution functions and use to developed statistical software	GA-5
4.	Understand the concepts of basic techniques of measuring the uncertainty problem and solve the real life problems,	GA-10

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 Code: MTH210

Course Title: Linear Algebra

Instructor: Nosheen

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Solve system of linear equation.	GA-3
2.	Solve problems using Echelon form.	GA-4
3.	To find the Eigen values & Eigen vectors.	GA-3
4.	How to transform the matrix & how to find the inverse.	GA-1

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 form

University Electives

Course-Code	Course Title	Credit Hr.	Category
SOC100	Sociology	3	University Electives
MGT100	Principles of Management	3	University Electives
ECON100	Basic Economics	3	University Electives

Course Code: SOC100

Course Title: Sociology

Instructor: Nadeem Arif

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Reflexive Capacity and understanding Social Phenomena	GA-8
2.	Development of Writing and Reading Skills	GA-7
3.	Group Work and Oral Presentation Skills	GA-6
4.	Inter-relational Competences	GA-10

Course Contents
Scope of Sociology, Importance of Sociology, Topic culture, Structural Functionalism, Social Conflict, Symbolic Interactionism & Test Conflict, Social Control, Agents of Social Control, Social Stratification & Social Mobility, Social Institution, Characteristics & Function, Family Religion Assignment Religion, Socialization, Agents of Socialization, Accommodation, Assimilation, Acculturation, Caste System Class System

Course Code: MGT-100

Course Title: Principles of Management

Instructor: Mr. Rehmatullah

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	After studying this course, students will be able to specify how the managerial tasks of planning, organizing, and controlling can be executed in a variety of circumstances.	GA-1
2.	They will be able to assess global situation, including opportunities and threats that will impact management of an organization.	GA-3
3.	The course will help them to integrate management principles into management practices.	GA-2
4.	They will be able to determine the most effective action to take in specific situations and evaluate approaches to addressing issues of diversity.	GA-4

Course Contents
Basic concept, Organization, Organizational type, Component of organization, Definition and process of Mgt. Other concept of management. SWOT analysis of organization, Foundation of basic element in planning, Decision making, Definition decision / nature of decision, Strategic management, Organizational structure, Human resources management, Leadership, team work and group behavior, staffing, Controlling, Definition of controlling, Nature of controlling Importance of controlling, Controlling process

Course Code: ECON100

Course Title: Basic Economics

Instructor: Mr. Alamgir khan

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understand consumer, Producer behavior, macroeconomic indicators issues, Environmental economics aspects of a country.	GA-1
2.	Apply graphical analysis for a variety of economic situations	GA-4
3.	Calculate and interpret elasticities.	GA-3
4.	Define and derive short-run and long-run production costs	GA-5
5.	Explain various market structures	GA-7

Course Contents
Introduction to economics school of thoughts; Microeconomics, macroeconomics, Scarcity, Consumer theory; Demand and Law of demand, schedule, graph, limitations; Utility, Law of diminishing marginal Utility, graph, limitations; Supply, law of supply, schedule, graph, determinants of supply; Equilibrium point. Surplus and shortage; Elasticity, types of elasticity; Indifference curve, properties of Indifference curve; Budget line, Marginal rate of substitution; Utility maximization through IC and budget line; Producer Behavior, objective of the producer; Cost, types of cost; Revenue , types of Revenue , Profit; Law of return to scale; Market, Types of markets; Markets based on economic competition (Introductory treatment); Basic Macroeconomics concepts; GDP, GNP , NNP , National Income, PC; Circular flow of national income; Real GDP vs Nominal GDP; Inflation , types of inflation and its causes; Consumer price index and its relationship with inflation; Economic problems of Pakistan; Interest rate, and its types; Unemployment and its types; Economic growth vs Economic development; Monetary Policy of Pakistan; Fiscal policy; Introduction to taxation; Sustainable Development Goals;

Domain Courses for BS (Software Engineering)
Software Engineering Core

Course-Code	Course Title	Credit Hr.	Category
SE210	Human computer Interaction	3	Software Engineering Core
SE211	Software Requirements Engineering	3	Software Engineering Core
SE212	Software Design & Architecture	2+1	Software Engineering Core
SE310	Software Construction & Development	2+1	Software Engineering Core
SE311	Software Quality Engineering	3	Software Engineering Core
SE212	Software Re-Engineering	3	Software Engineering Core
SE313	Web Engineering	3	Software Engineering Core
SE410	Software Project Management	3	Software Engineering Core

Course Code: SE210

Course Title: HCI

Instructor: Tayyaba

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain context of HCI and different measures for evaluation.	GA-2
2.	Apply the principles of good design for people from the perspective of age and disabilities	GA-4
3.	Analyze techniques for user centered design for a medium sized software	GA-3
4.	Evaluate the usability of a medium size software user interface.	GA-4

Course Contents
Introduction to human-computer interaction and the design of systems that work for people and their organizations. The goal is to understand the manner in which humans interact with, and use, their computers for productive work. The course focus is on the interface as designed artifact. The interface is a design problem without a single "correct" solution but which has many "good" solutions and a plethora of "bad" solutions. Class discussion centers on what makes an interface good and proven techniques for designing interfaces that meet human needs.

Course Code: SE211

Course Title: Software Requirements Engineering

Instructor: Mr. Ibrar Afzal

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate Attributes
1.	Describe the requirements engineering process	GA-3
2.	Effectively analyze software requirements for the development of cost-effective and efficient technical solutions.	GA-3
3.	Prepare both functional and non-functional requirements along with validation for a medium-size software system.	GA-4
4.	Document effective requirements in Software Requirements Specification (SRS) using clear, unambiguous requirements.	GA-5

Course Contents

Introduction to Requirements Engineering, Software Requirements, 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 Code: SE212

Course Title: Software Design & Architecture

Instructor: Romana saleem

Credit Hours: 3(2+1)

Course Learning Outcomes (CLO's):

Serial#	CLO	GA
1	Understand the role of design and its major activities within the OO software development process, with focus on the Unified process.	GA-2
2	Design OOD models and refine them to reflect implementation details.	GA-4
3	Apply and use UML to visualize and document the design of software systems.	GA-6
4	Implement the design model using an object-oriented programming language	GA-5

S. No.	Course Learning Outcome (CLO's) of Lab	Graduate attributes
1.	To capture the requirement specifications for an intended s/w system	GA-2
2.	To draw the UML diagrams for the given specification	GA-5
3.	To properly map the design to code.	GA-4
4.	To improve the design by applying appropriate design patterns.	GA-3

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 Code: SE310

Course Title: Software Construction & Development

Instructor: Nadir Hussain

Credit Hours: 3(2+1)

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate Attributes
1.	Understand the role of design and its major activities within the OO software development process, with focus on the Unified process	GA-2
2.	Develop Object-oriented design models and refine them to reflect implementation details	GA-4
3.	Evaluate different architectures for a medium size software.	GA-3
4.	Implement design model using an object-oriented programming language.	GA-5

S. No.	Course Learning Outcome (CLO's) of LAB	Graduate Attributes
1.	Refactoring and Exception Handling in JAVA	GA-3
2.	Implementing a small project using JAVA by MVC-architecture	GA-4
3.	Modern GUI development in JAVA	GA-5

Course Contents
Software development process, Software engineering process infrastructure, Software engineering process improvement, Systems engineering life cycle models, Process implementation, Levels of process definition, Life cycle model characteristics, Individual and team software process, Lehman's Laws, code salvaging, and configuration management. Martin Fowler's refactoring concepts and their application to small projects. Apply Michael Feathers' "legacy code" concepts. Exception handling, making methods robust by having them check their inputs sent from calling objects. Software configuration management, Release management, Software configuration management processes, Software deployment processes, Distribution and backup, Evolution processes and activities, Basic concepts of evolution and maintenance, Working with legacy systems, Refactoring, Error handling, exception handling, and fault tolerance. Personal reviews (design, code, etc.), Peer reviews (inspections, walkthroughs, etc.).

Course Code: SE311

Course Title: Software Quality Engineering

Instructor: Dr. Faisal Bahadur

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate Attributes
1.	outline software testing and software quality assurance principles	GA-2
2.	prepare test case and test suites for completely testing all aspects of a system under test	GA-4
3.	Analyze which of the software testing techniques are relevant for a particular case and know software reliability analysis tools and techniques	GA-3
4.	Analyze when to use of Test Automation . How to use it.	GA-5

Course Contents

Software Quality, Software Quality Attributes, Quality Engineering., Testing: Concepts, Issues, and Techniques, Software testing lifecycle., Testing Scopes., Testing Approaches., Testing Concepts., Test Planning Process, Introduction to testing process, Requirement of software test planning, Testing documentation, Software testing techniques, Testing philosophies , Testing strategies, Model based testing, Software testing techniques, Testing using models, Domain and combinatorial testing, Unit and integration testing, Acceptance testing, Test automation, Slicing, Software reliability models and engineering, Introduction, Exponential model., Reliability growth models, Software inspections, Software reviews, Inspection checks and metrics, Quality Models, Models for quality assessment, Product quality metrics, Quality Measurements, System testing, Introduction to sub-system testing, From functional to system aspects of testing, System testing, Introduction to system testing, Scenarios development, System testing, Use-cases for testing, Specification-based testing, Open issues on software testing

Course Code: SE312

Course Title: Software Re-Engineering

Instructor: Mr. Faqir Gul

Credit Hours:3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Explain the concepts and technique of software reengineering.	GA-2
2.	Apply reengineering techniques to maintain and modify software systems	GA-4
3.	Analyze and understand maintenance related problems associated with object oriented software systems.	GA-3
4.	Able to perform complex design reengineering and reverse engineering problems.	GA-4

Course Contents
Salient topics include the terminology and the processes pertaining to software evolution, fundamental re-engineering techniques to modernize legacy systems including source code analysis, architecture recovery, and code restructuring, software refactoring strategies, migration to Object Oriented platforms, quality issues in re-engineering processes, migration to network-centric environments, and software integration, reverse engineering, program comprehension, source code transformation and refactoring strategies, software maintenance and re-engineering economics.

Course Code: SE313

Course Title: Web Engineering

Instructor: Dr. Zulfiqar Ahmad

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Discuss how web standards impact software development.	GA-2
2.	Describe the constraints that the web puts on developers.	GA-3
3.	Design and Implement a simple web application.	GA-4
4.	Review an existing web application against a current web standard.	GA-5

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 Code: SE410

Course Title: Software Project Management

Instructor: Faqir Gul

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Explain principles of the project lifecycle and how to identify opportunities to work with learners on relevant and appropriate project scenarios to share this understanding	GA-1
2.	Critically evaluate and discuss the issues around project management and its application in the real world with course participants and learners	GA-2
3.	Choose project management techniques for IT projects to initiate, plan, execute and evaluate a project and work in teams to create a project plan for a project scenario that includes key tasks, critical path, dependencies and a realistic timeline.	GA-3
4.	Present strategies for gaining confidence in managing projects through simple project planning examples.	GA-4

Course Contents
Introduction to Software Project Management, Project Management concepts, Project Management Tools, PMI's Knowledge areas, PMI Framework, PMI Process Groups. Understanding Organizations. Project Planning, Project Evaluation, Selection of an Appropriate Approach in Project, Software Effort Estimation, Activity Planning, Risk Management, Evaluating the Risks to the Schedule, Risk Control, Configuration Management and Maintenance, Environment for Configuration Control, Resource Allocation, Monitoring & Control, Review and Evaluation, Challenges of Outsourcing in Project Management

Software Engineering SUPPORTING courses.

Course-Code	Course Title	Credit Hr.	Category
SE330	Formal Methods in Software Engineering	3	Software Engineering Supporting
SE331	Simulation and Modelling	3	Software Engineering Supporting

Course Code: SE330

Course Title: Formal Methods in Software Engineering

Instructor: Mr. Imran Khan

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Explain different concepts of formal methods, models, specifications, validation and verification of systems.	GA-2
2.	Analyze and argue about the correctness of program using formal methods(such as Hoare's logic)	GA-3
3.	Model (software) systems(e.g. Concurrent system) using formal methods	GA-4
4.	Specifying Software Systems using formal specification Languages (such as VDM and Z)	GA-4

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 and Formal analysis, An introduction to VDM, Sets, Sequences, Proofs, Introduction to Z Specification.

Course Code: SE331

Course Title: Simulation and Modeling

Instructor: Ibrar Afzal

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's)	Graduate Attributes
1.	Explain the model classification at different levels.	GA-2
2.	Analyze complex engineering systems and associated issues (using systems thinking and modelling techniques)	GA-3
3.	Apply advanced theory-based understanding of engineering fundamentals and specialist bodies of knowledge in the selected discipline area to predict the effect of engineering activities.	GA-5
4.	Analyze the simulation results of a medium sized engineering problem.	GA-3

Course Contents
Introduction to modelling and simulation, System analysis, Classification of systems, System theory basics, its relation to simulation, Model classification at conceptual, abstract, and simulation models levels, Methodology of model building, Simulation systems and languages, Means for model and experiment description, Principles of simulation system design, Parallel process modeling using Petri nets and finite automata in simulation, Models of queuing systems, Discrete simulation models, Model time, Simulation experiment control, Overview of numerical methods used for continuous simulation. System Dymola/ Modelica, Combined simulation, Special model classes, Models of heterogeneous systems, Cellular automata and simulation, Checking model validity, Verification of models, Analysis of simulation results, simulation results visualization, model optimization, generating, transformation, and testing of pseudorandom numbers with overview of commonly used simulation system

Software Engineering ELECTIVE courses.

Course-Code	Course Title	Credit Hr.	Category
CS423	Cloud Computing	3	Software Engineering Elective
CS422	Internet of things	3	Software Engineering Elective
CS421	Mobile App Development	3	Software Engineering Elective
SE422	Software Metrics	3	Software Engineering Elective
SE424	Failure Analysis & Recovery	3	Software Engineering Elective

Course Code: CS423

Course Title: Cloud Computing

Instructor: Asif Umer

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's)	Graduate attributes
1.	Understanding basic concepts of distributed systems	GA-1
2.	Understanding of cloud computing technologies	GA-2
3.	Understanding of Virtualization and its various flavors	GA-4
4.	Ability to address large scale data processing challenges	GA-3

Course Contents
Introduction to Cloud Computing, History and Background of Cloud Computing, Basics of Computers, Basics of Data Communication Basics of Computer Networking Advanced Topics of Computer Networks Virtualization Essential Characteristics of Cloud Computing Benefits of Cloud Computing Risks and Challenges of Cloud Computing Roles and Boundaries of Cloud Computing Cloud Service Models Data Storage in Clouds Miscellaneous Services of Cloud Computing Cloud Deployment Models Service Oriented Architecture Cloud Security Threats Trust Issues in Cloud Mechanisms Related to Cloud Infrastructure Service Agreements Cloud Hosting Data Center Design Cloud Architecture Specialized Cloud Mechanisms Cloud Management Fundamental Cloud Architectures Advanced Cloud Architectures Cloud Federation Cloud Delivery/Service Models' Perspectives Inter-Cloud Resource Management Cloud Cost Metrics and Pricing Models Cloud Service Quality Metrics Cloud Simulator Computer Security Basics Network Security Basics Cloud Security Mechanisms Privacy Issues of Cloud Computing Security Issues of Cloud Computing Trust Issues of Cloud Computing Open Issues in Cloud Disaster Recovery in Cloud Computing Migrating to the Cloud Cloud Application Scalability and Resource Scheduling Mobile Cloud Computing.

1.

Course Code: CS422

Course Title: Internet of Things

Instructor: Asif Umer

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	A paradigm that connects physical objects and devices to the Internet, enabling them to collect and exchange data for various applications. Students will explore the	GA-2
2.	Apply the fundamental principles, technologies, and applications of IoT, as well as the challenges and opportunities it presents in the modern digital world.	GA-3
3.	Use the concept of IoT security to make sure the secure communication of IoT devices.	GA-3

Course Contents
Physical devices such as sensors, actuators, Arduino etc. Network technologies for the IoT devices connectivity such as Cellular technologies, WiFi, and ethernet. NB-IoT, NFC, RFID, BLE, SigFox, ZigBee etc. IPv6 and IPv4 for source to destination communication. Edge computing such as Cloud, Fog, and Edge Servers. Data Accumulation and abstraction such as structured data and un-structured data. Applications used for IoT devices and business collaboration.

Course Code: CS421

Course Title: Mobile Application Development

Instructor: Shahid Khan

Credit Hours: 3

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Deliberate different architectures & framework for Mobile Application development	GA-2
2.	Develop mobile applications using current software development environments.	GA-4
3.	Compare the different performance tradeoffs in mobile application development	GA-3
4.	Implement a small module using Android programming.	GA-6

Course Contents
Mobiles Application Development Platform; HTML5 for Mobiles; Android OS: Architecture, Framework and Application Development; iOS: Architecture, Framework; Application Development with Windows Mobile; Eclipse; Fragments; 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; Getting Feedback; Sending Email; Displaying Maps; Consuming Web Services Using HTTP; Web Services: Accessing and Creating; Threading; Publishing, Android Applications; Deployment on App Stores; Mobile Programming Languages; Challenges with Mobility and Wireless Communication; Location-aware Applications; Performance/Power Tradeoffs; Mobile Platform Constraints; Emerging Technologies.

Course Code: SE422

Course Title: Software Metrics

Instructor: Dr.Asfandyar Khan

Credit Hours: 3

Course Learning Outcomes (CLO's):

CLO. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Classify theories and models for measurements in software engineering	GA-2
2.	Discuss goal based framework for software measurement	GA-2
3.	Apply empirical analysis for measurements in software engineering	GA-3
4.	Perform decision making using statistical analysis on a set of data	GA-4
5.	Distinguish internal and external software product attributes	GA-5

Course Contents
Software Measurement: Overview of Measurements, Objectives, Measurement for Understanding, Control & Improvements, Scope, Representational Theory, Models, Scales & Types, and Statistical & Subjective Measures. Goal Based Frameworks for Software Measurement: Software Measures Classification, Determine What to Measure?, and Software Measurement Application & Validation. Empirical Investigation: Principles, Planning, Experiments, and Case Studies (Quasi- Experiments). Software Metrics Data Collection & Analysis: Data Collection Methods & Reliability, Statistical Data Analysis Techniques, and Multi Criteria Decision Aids. Metrics for Decision Support: Application of Bayes Theorem and Bayesian Network. Software Engineering Measurement: Measuring Internal Product Attributes, and Size and Structure. Measuring External Product Attributes. Software Reliability: Measurement and Prediction

Course Code: SE424

Course Title: Failure Analysis & Recovery

Instructor: Dr. Faisal Bahadur

Credit Hours: 3

Course Learning Outcomes (CLO's):

Serial#	CLO	GA	
1	Detailed information of all software defect categories at all levels of SDLC	GA2	
2	Analyze and manage the software defect	GA3	
3	Recover the defect by inspections and testing	GA4	
4	Use of bug trackers in the s/w defect management	GA5	

Course Contents
Software errors, defects, and failures, Detailed Descriptions of S/W Quality characteristics, Requirements Problems and Requirements Defects, Design Defects, Coding Defects, Defect/Failure Elimination strategies, Inspection, Testing: Concepts, Principles Activities, Test Planning and Preparation, Levels of Testing, Defect Management, Defect Analysis, Risk Identification

Course Code: SE423

Course Title: Software Testing

Instructor: Faqir Gul

Credit Hours: 3

Course Learning Outcomes (CLO's):

S. No.	Course Learning Outcome (CLO's) of Theory	Graduate attributes
1.	Understanding the principles of software testing, including the importance of testing in the software development lifecycle, different testing methodologies, and the roles and responsibilities of a software tester.	GA-1
2.	Applying various testing techniques and strategies, such as black-box, white-box, and grey-box testing, to effectively test software applications and designing and executing test cases to uncover software defects.	GA-2
3.	Developing skills in implementing automated testing tools and frameworks, enabling them to conduct efficient and effective testing to gain hands-on experience with tools like JUnit, or TestNG to automate test processes	GA-5
4.	Understanding how to plan, manage, and execute testing projects, including test planning, test design, test execution, defect tracking, and reporting and how to use test management tools to streamline these processes.	GA-3
5.	Analyzing test results, identifying patterns in software defects, and making recommendations for software quality improvements and introducing current trends and emerging practices in software testing	GA-4

Course Contents
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.

4. Program Learning Outcomes (PLOs) or GA

1. *Academic Education* – Completion of an accredited program of study designed to prepare graduates as computing professionals.
2. *Knowledge for Solving Computing Problems* – Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements.
3. *Problem Analysis* – Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.
4. *Design/Development of Solutions* – Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
5. *Modern Tool Usage* – Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.
6. *Individual and Teamwork* – Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.
7. *Communication* – Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions.
8. *Computing Professionalism and Society* – Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.
9. *Ethics* – Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.
10. *Life-long Learning* – Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

Upon completion of BS (AI), BS (CS), and BS (SE) degree, all the students should have attained the aforementioned ten GAs.