Bachelor of Science in Artificial Intelligence - BSAI

The BS (AI) program gives the students an in-depth knowledge they need to transform large and complex scenarios into actionable decisions. The program and its curriculum focus on how complex inputs from the universe e.g. weather, galaxies, vegetations, human senses (vision, audio, smell, taste, touch), perceptions, actions, emotions, human biology, languages and various such disciplines in conjunction with databases are designed, processed and used to make logical decisions via queries, reasoning, automation and betterment of existing systems and environment. The curriculum of the BS (AI) program includes coursework in foundations of mathematics, linear algebra, statistics, computing, automated reasoning, modeling, case studies, machine learning, natural language processing, artificial neural networks, large language models using classical till contemporary generations of artificial intelligence models e.g. deep neural networks, graph neural networks, generative artificial intelligence. The program also encourages students to take courses in ethics and social responsibility, with the opportunity to participate in long term projects in which artificial intelligence can be applied to solve problems that can change the world for the better — in areas like agriculture, defense, healthcare, governance, transportation, e-commerce, finance and education.

Proposed Curriculum for
Bachelor of Science in Artificial Intelligence (BSAI) Program

Proposed curriculum (semester-wise course plan and contents of the courses) for BSAI Program is given below as per the recommendations of NCEAC, HEC and Board of Studies of University of Karachi.

Summary Table for Total Number of courses offered and credit hours in the program - BSAI

Course Categories	Number of Courses	Credit Hours
Computing Core + Capstone Project	16	54
Domain Core	6	18
Domain Elective	5	15
Mathematics & Supporting Courses	4	12
General Education Requirement + Internship	15	39
Professional Certification	1	3
Total Number of Courses and Credit Hours	**47**	**141**

Semester-wise Course Plan

Course Code	Course Name	Credit Hrs.
AI-351	Programming Fundamentals	4 (3+1)
AI-353	Applications of Information & Communication Technologies	3 (3+0)
AI-355	Calculus and Analytical Geometry	3 (3+0)
AI-357	Applied Physics	3 (2+1)
AI-359	Functional English	3 (3+0)
AI-361	Islamic Studies or Ethics	2 (2+0)
Total Credits for Semester – I		**18**

Course Code	Course Name	Credit Hrs.
AI-352	Object Oriented Concepts & Programming	4 (3+1)
AI-354	Digital Logic Design	3 (2+1)
AI-356	Linear Algebra	3 (3+0)
AI-358	Discrete Structures	3 (3+0)
AI-360	Expository Writing	3 (3+0)

AI-362	Ideology and Constitution of Pakistan	2 (2+0)
AI-364	Pakistan Studies	2 (2+0)
Total Credits for Semester – II		**20**

Course Code	Course Name	Credit Hrs.
AI-451	Data Structures and Applications	4 (3+1)
AI-453	Software Engineering Fundamentals	3 (3+0)
AI-455	Computer Organization & Assembly Language	3 (2+1)
AI-457	Multivariable Calculus	3 (3+0)
AI-459	Probability & Statistics	3 (3+0)
AI-461	Urdu	2 (2+0)
Total Credits for Semester – III		**18**

Course Code	Course Name	Credit Hrs.
AI-452	Database Management Systems	4 (3+1)
AI-454	Artificial Intelligence	3 (2+1)
AI-xxx	Domain Elective-1	3
AI-444	Fehm e Quran	2(2+0)
AI-456	Data Communication and Networking	3 (2+1)
Total Credits for Semester – IV		**15**

Course Code	Course Name	Credit Hrs.
AI-551	Programming for AI	3 (2+1)
AI-553	Operating Systems	3 (2+1)
AI-555	Machine Learning	3 (2+1)
AI-561	Financial Accounting	3 (3+0)
AI-557	Information Security	3 (2+1)
AI-559	Civics and Community Engagement	2 (2+0)
Total Credits for Semester – V		**17**

Course Code	Course Name	Credit Hrs.
AI-552	Artificial Neural Networks & Deep Learning	3 (2+1)
AI-554	Professional Practices	3 (2+1)
AI-556	Design and Analysis of Algorithms	3 (3+0)
AI-558	Technical and Business Writing	3 (3+0)
AI-xxx	Domain Elective-2	3
AI-xxx	Domain Elective-3	3
Total Credits for Semester – VI		**18**

Course	Course Name	Credit

Code		Hrs.
AI-610	Professional Certification	3(0+3)
AI-xxx	Domain Elective-4	3
AI-651	Computer Vision	3 (2+1)
AI-653	Internship	3 (0+3)
AI-655 Or AI-657	Final Year (Capstone) Project – I Or Thesis – I	3 (0+3) Or 3 (3+0)
Total Credits for Semester - VII		**15**

Course Code	Course Name	Credit Hrs.
AI-xxx	Domain Elective-5 **(Topic of Current Interest)**	3
AI-652	Parallel & Distributed Computing	3 (2+1)
AI-660	Entrepreneurship	3 (3+0)
AI-654	Knowledge Representation and Reasoning	3 (3+0)
AI-656 Or AI-658	Final Year (Capstone) Project – II Or Thesis – II	3 (0+3) Or 3 (3+0)
Total Credits for Semester - VIII		**15**

Artificial Intelligence Domain Core (DC):

BS - Artificial Intelligence Domain Core (18/137) 6 Courses		
DC S#	**Course Title**	**Cr. Hrs.**
1	Programming for AI	3
2	Machine Learning	3
3	Artificial Neural Networks & Deep Learning	3
4	Knowledge Representation and Reasoning	3
5	Computer Vision	3
6	Parallel & Distributed Computing	3

Artificial Intelligence Domain Elective (DE):

BS - Artificial Intelligence Domain Elective (21/137) 7 Courses

Course Code	Domain Elective DE-1	Credit Hrs.
AI-471	Theory of Automata	3 (3+0)
AI-472	Numerical Analysis and Computing	3 (3+0)

AI-473	Simulation and Modeling	3 (3+0)
Course Code	**Domain Elective DE-2, 3**	**Credit Hrs.**
AI-571	Operations Research	3 (3+0)
AI-572	Agent Based Simulation and Modeling	3 (3+0)
AI-573	Fuzzy Systems	3 (3+0)
AI-574	Reinforcement Learning	3 (3+0)
AI-575	Social Network Analysis	3 (3+0)
AI-576	Mobile Applications Development	3 (2+1)
AI-577	HCI & Computer Graphics	3 (2+1)
AI-578	Internet of Things	3 (2+1)
Course Code	**Domain Elective DE-4, 5**	**Credit Hrs.**
AI-671	Natural Language Processing	3 (3+0)
AI-672	Speech Processing	3 (3+0)
AI-673	Swarm Intelligence	3 (3+0)
AI-674	Data Warehousing and Data Mining	3 (2+1)
AI-675	Cyber Security	3 (2+1)
AI-676	Web Engineering	3 (2+1)
AI-677	Bioinformatics	3 (3+0)
AI-678	Complex Networks	3 (3+0)
AI-680	Topic of Current Interest (Domain Elective-5)	3 (3+0)

Computing Core (CC):

Computing Core (54/141) 16 Courses (common to all computing programs)		
S#	**Course Title**	**Cr. Hrs.**
1.	Programming Fundamentals	4 (3+1)
2.	Object Oriented Programming	4 (3+1)
3.	Database Systems	4 (3+1)
4.	Digital Logic Design	4 (3+1)
5.	Data Structures	4 (3+1)
6.	Information Security	3 (3+0)
7.	Artificial Intelligence	3 (2+1)
8.	Data Communication and Networking	3 (2+1)
9.	Software Engineering	3 (3+0)
10.	Computer Organization & Assembly Language	3 (2+1)
11.	Operating Systems	4 (3+1)

12.	Analysis of Algorithms	3 (3+0)
13.	Theory of Automata	3 (3+0)
14.	Cloud Computing	3 (3+0)
15.	Final Year Project – I	3 (0+3)
16.	Final Year Project – II	3(0+3)

Mathematics & Supporting Courses (MS):

BS - Artificial Intelligence Mathematics & Supporting Courses (12/137) 4 Courses		
Course Code	**Course Title**	**Cr. Hrs.**
AI-356	Linear Algebra	3
AI-457	Multivariable Calculus	3
AI-459	Probability & Statistics	3
AI-558	Technical and Business Writing	3

Elective Supporting Courses (ES):

BS - Artificial Intelligence Elective Supporting Courses (3/137) 1 Course		
Course Code	**Course Title**	**Cr. Hrs.**
AI-561	Social Science (**Financial Accounting)**	3

General Education Requirement (GE):

BS – Software Engineering General Education Requirement (39/141) 15 Courses		
Sr. No.	**Course Title**	**Cr. Hrs.**
1.	Introduction to Information & Communication Technologies	3
2.	Functional English	3
3.	Expository Writing	3
4.	Quantitative Reasoning – 1 (Discrete Structures)	3
5.	Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	3
6.	Islamic Studies	2
7.	Ideology and Constitution of Pakistan	2
8.	Natural Science (**Applied Physics**)	3
9.	Arts & Humanities (**Professional Practices**)	3

10.	Civics and Community Engagement	2
11.	Entrepreneurship	3
12.	Social Sciences (**URDU**)	2
13.	Fehm e Quran	2
14.	Pakistan Studies	2
15.	Internship	3

Course Outlines

Computing Core (54/141) 16 Courses (common to all computing programs)		
S#	**Course Title**	**Cr. Hrs.**
17.	Programming Fundamentals	4 (3+1)
18.	Object Oriented Programming	4 (3+1)
19.	Database Systems	4 (3+1)
20.	Digital Logic Design	4 (3+1)
21.	Data Structures	4 (3+1)
22.	Information Security	3 (3+0)
23.	Artificial Intelligence	3 (2+1)
24.	Data Communication and Networking	3 (2+1)
25.	Software Engineering	3 (3+0)
26.	Computer Organization & Assembly Language	3 (2+1)
27.	Operating Systems	4 (3+1)
28.	Analysis of Algorithms	3 (3+0)
29.	Theory of Automata	3 (3+0)
30.	Cloud Computing	3 (3+0)
31.	Final Year Project – I	3 (0+3)
32.	Final Year Project – II	3(0+3)

Course Name: **Programming Fundamentals (AI-351)**
Credit Hours: **4 (3+1)**
Contact Hours: **3-3**
Pre-requisites: **None**

Course Introduction:

This course provides fundamental concepts of programming to freshmen. The course is pre-requisite to many other courses; therefore, students are strongly advised to cover all contents. In theory part programing concepts are covered in depth and in the lab the same concepts will be covered with C/C++.

Course Objectives:

This course will introduce powerful problem-solving techniques. The main objective of this course is to learn how to develop an algorithm and conceptualize modules. Then the course will progress to code reading, writing, interaction between modules and debugging along-with understanding of input, output, processing, syntax errors and logical errors.

Course Learning Outcomes:

1. Understand problem-solving and logic constructs
2. Implement programing concepts
3. Design and implement algorithms to solve real world problems

Course Outline:

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.

Reference Materials (or use any other standard and latest books):

1. Starting out with Programming Logic & Designs, Tony Gaddis (6th edition, published by Pearson (June 21, 2022) © 2023
2. The C Programming Language, Brian W. Kernighan, Dennis M. Ritchie (2nd edition) (March 22, 1988)
3. Problem Solving and Program Design in C++, Jeri R. Hanly & Elliot B. Koffman (Edition. 8th · Publisher. Pearson · Publication date. February 17, 2015)
4. Java: The Comprehensive Guide to Java Programming for Professionals (Rheinwerk Computing), Christian Ullenboom, 2023 (Standard edition 17)
5. Python Programming for Beginners, ISBN 13 979-8876939234, codeprowess 2024 (Year of publication 2020)

Course Name: **Object-Oriented Concepts & Programming (AI-352)**
Credit Hours: **4 (3+1)**
Contact Hours: **3-3**
Pre-requisites: **Programming Fundamentals**
Course Introduction:
The course aims to focus on object-oriented concepts, analysis and software development. The basic concept of OOP is covered in this course.

Course Objectives:
Introduce the principles of object-oriented programming in a higher-level programming language, such as Python or Java. Analyze a problem statement to develop a mental model of objects necessary to create software architecture. Utilize object-oriented programming to frame software architectures, with care towards separation of concerns and abstraction. Gain skills in designing and programming software for reuse of code. Establish development methods in object-oriented programming to qualify students for teaching the language in other settings

Course Learning Outcomes:
1. Understand principles of object-oriented paradigm.
2. Identify the objects and their relationships to build object-oriented solution
3. Model a solution for a given problem using object-oriented principles
4. Examine an object-oriented solution

Course Outline:
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.

Reference Materials: (or use any other standard and latest books):
1. Java: How to Program, Paul Deitel (11th edition)) February 20, 2017)
2. Beginning Java 2, Ivor Horton (5th edition))) January 1, 2005)
3. An Introduction to Object Oriented Programming with Java, C. Thomas Wu (5th edition) (March 24, 2009)
4. Starting Out with C++ from Control Structures to Objects, Tony Gaddis (10th edition) (August 15, 2022)
5. C++ How to Program, Deitel & Deitel. (11th edition)(July 27, 2023)
6. Object Oriented Programming in C++, Robert Lafore (4th edition)(January 1, 2001)

Course Name: **Digital Logic Design (AI-354)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **None**

Course Introduction:
The course introduces the concept of digital logic, gates and the digital circuits. Further, it focuses on the design and analysis of combinational and sequential circuits. It also serves to familiarize the student with the logic design of basic computer hardware components.

Course Objectives:
The purpose is to make students familiar with modern hierarchy of digital hardware and enlighten them the state-of-the-art computer hardware design methodologies. Moreover, the contents of the course provide students with the basic idea of how to design and simulate logic circuits.

Course Learning Outcomes:
1. Acquire knowledge related to concepts, tools and techniques for the design of digital electronic circuits
2. Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques
3. Apply the acquired knowledge to simulate and implement small-scale digital circuits
4. Understand the relationship between abstract logic characterizations and practical electrical implementations

Course Outline:
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. Mealy machines and Moore machines. 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 (or use any other standard and latest books):
1. Digital Fundamentals by Floyd (11^{th} edition)(July 14, 2014)
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown (3^{rd} edition) **(**February 12, 2013)
3. Digital Design: Principles and Practices 5th by John Wakerly. Publisher Pearson (5^{th} edition) Publication Date July 24, 2018.
4. Digital Logic Design: A Rigorous Approach, Guy Even, Moti Medina. 2019

Course Name: **Data Structures and Applications (AI-451)**
Credit Hours: **4 (3+1)**
Contact Hours: **3-3**
Pre-requisites: **Programming Fundamentals, OOP**

Course Introduction:

The course is designed to teach students structures and schemes, which allow them to write programs to efficiently manipulate, store, and retrieve data. Students are exposed to the concepts of time and space complexity of computer programs.

Course Objectives:

Main objective of this course is to enable students to understand and implement common data structures and algorithms for computing and manipulation using C++ techniques. Emphasis will be on a lot of practice in writing codes to implement all the major data structures.

Course Learning Outcomes:

1. Implement various data structures and their algorithms and apply them in implementing simple applications
2. Analyze simple algorithms and determine their complexities
3. Apply the knowledge of data structure to other application domains
4. Design new data structures and algorithms to solve problems

Course Outline:

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.

Reference Materials: (or use any other standard and latest books):

1. Data Structures and Algorithm Analysis in Java by Mark A. Weiss (3rd edition) (November 18, 2011)
2. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry (5th edition) (March 1, 2018)
3. Data Structures and Algorithms in C++ by Adam Drozdek (4th edition) (August 27, 2012)
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss (4th edition) (June 13, 2013)
5. Java Software Structures: Designing and Using Data Structures by John Lewis and Joseph Chase (4th edition) (February 25, 2013)

Course Name: **Database Management Systems (AI-452)**
Credit Hours: **4 (3+1)**
Contact Hours: **3-3**
Pre-requisites: **None**

Course Introduction:

The course aims to introduce basic database concepts, different data models, data storage and retrieval techniques and database design techniques. The course primarily focuses on relational data model and DBMS concepts.

Course Objectives:

To introduce the concepts and techniques in database design and implementation. To develop understanding of relational algebra and relational query languages. To provide experience of database application development

Course Learning Outcomes:

1. Explain fundamental database concepts
2. Design conceptual, logical and physical database schemas using different data models
3. Identify functional dependencies and resolve database anomalies by normalizing database tables
4. Use Structured Query Language (SQL) for database definition and manipulation in any DBMS

Course Outline:

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 and calculus , selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Relational Database Design Using ER-to-Relational Mapping, Mapping EER Model Constructs to Relations, Disk Storage, Basic File Structures, Hashing, and Modern Storage Architectures, Introduction to Transaction Processing, Transaction and System Concepts, Desirable Properties of Transactions, Structured Query Language (SQL), Joins and sub- queries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, introduction to NoSQL systems.

Reference Materials: (or use any other standard and latest books)

1. Database Systems: A Practical Approach to Design, Implementation, and Management by Thomas Connolly and Carolyn Begg (6^{th} edition) (January 8, 2014)
2. Fundamentals of Database System, Ramez Elmasri & Shamkant B. Navathe, published by Pearson ISBN-10: 0-13-397077-9, ISBN-13: 978-0-13-397077-7 (7^{th} edition) (June 8, 2015)
3. Database Systems: The Complete Book by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom (2^{nd} edition)(June 5, 2008)
4. Database System Concepts by Avi Silberschatz, Henry F. Korth and S. Sudarshan. (7^{th} edition) (February 19, 2019)
5. Next slide of product details
6. Database Management Systems by Raghu Ramakrishnan, Johannes Gehrke (3^{rd} edition) (August 14, 2002)

Course Name: **Software Engineering Fundamentals (AI-453)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:

This course provides a comprehensive introduction to the essential principles and practices of software development. You'll explore the software development lifecycle, requirements analysis, system design, testing methodologies, and project management techniques. Designed for beginners and aspiring professionals, this course equips you with the foundational skills needed to build high-quality software and effectively collaborate within teams. Join us to kickstart your journey in the dynamic world of software engineering!

Course Learning Outcomes:

1. Describe various software engineering processes and activates
2. Apply the system modeling techniques to model a medium size software system
3. Apply software quality assurance and testing principles to medium size software systems
4. Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis

Course Objectives

The goal of software engineering course applies a disciplined and organized approach to software development with the stated goal of improving quality, time and budget efficiency, along with the assurance of structured testing and engineer Certification.

Course Outline:

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 (or use any other standard and latest books):

1. Software Engineering, Sommerville, Pearson Inc. (10^{th} edition) (March 24, 2015)
2. Software Engineering, A Practitioner's Approach, Pressman R. S.& Maxim B. R., McGraw-Hill (9^{th} edition) (September 9, 2019)

Course Name: **Artificial Intelligence (AI-454)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites:
Course Introduction:
Artificial Intelligence has emerged as one of the most significant and promising areas of computing. This course focuses on the foundations of AI and its basic techniques like Symbolic manipulations, Pattern Matching, Knowledge Representation, Decision Making and Appreciating the differences between Knowledge, Data and Code. AI programming language Python has been proposed for the practical work of this course.

Course Objectives:
Study the concepts of Artificial Intelligence. Learn the methods of solving problems using Artificial Intelligence. Learn the knowledge representation techniques, reasoning techniques and planning. Introduce the concepts of Expert Systems and machine learning.

Course Learning Outcomes:
1. Understand the fundamental constructs of programming languages used for AI
2. Understand key concepts in the field of artificial intelligence
3. Implement artificial intelligence techniques and case studies

Course Outline:
An Introduction to Artificial Intelligence concepts and applications, Agents and Environments, Good Behavior: The Concept of Rationality, the Nature of Environments, the Structure of Agents towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Knowledge-Based Agents, introduction to Logic, propositional logic syntax, semantics and applications, FOL, syntax semantics and applications agents based on propositional logic and FOL. Knowledge engineering in FOL.
Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min- max algorithm, Alpha beta pruning, Game-playing); Learning from examples; ANN and Natural Language Processing; Recent trends in AI and applications of AI algorithms. Python programming language will be used to explore and illustrate various issues and techniques in Artificial Intelligence.

Reference Materials: (or use any other standard and latest books)

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", Prentice Hall, Inc. (4th edition) (May 8, 2020)
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc. (October 15, 1991)
3. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. (6th edition) (August 25, 2008)
4. Severance, C.R., 2016. "Python for everybody: Exploring data using Python 3." CreateSpace Independent Publ Platform. (3rd edition) (April 9, 2016)
5. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. "Python programming in context." Jones & Bartlett Pub. (4th edition) (April 17, 2024)
6. Joshi, P., 2017. "Artificial intelligence with python." Packt Publishing Ltd. (2nd edition) (January 26, 2017)

Course Name: **Computer Organization and Assembly Language (AI-455)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **Digital Logic Design**

Course Introduction:

The main objective of this course is to introduce the organization of computer systems and usage of assembly language for optimization and control. Emphasis should be given to expose the low-level logic employed for problem solving while using assembly language as a tool. At the end of the course the students should be capable of writing moderately complex assembly language subroutines and interfacing them to any high-level language.

Course Objectives

The main objective of this course is to introduce the organization of computer systems and usage of assembly language for optimization and control. Emphasis is given to expose the low-level logic employed for problem solving while using assembly language as a tool. At the end of the course the students should be able to: Identify the major components of computer architecture, and explain their purposes and interactions. Simulate the internal representation of data, and show how data is stored and accessed in memory. Explain the relationships between hardware architecture and its instruction set, and simulate micro-programs. Explain the Instruction Execution Cycle. Explain the differences and relationships among high-level, assembly, and machine languages. Write well-modularized computer programs in an assembly language, implementing decision, repetition, and procedure structures. Write moderately complex assembly language subroutines and interfacing them.

Course Learning Outcomes

1. Acquire the basic knowledge of computer organization computer architecture and assembly language
2. Understand the concepts of basic computer organization, architecture, and assembly language techniques
3. Solve the problems related to computer organization and assembly language

Course Outline:

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

Reference Materials: (or use any other standard and latest books)

1. Computer System Architecture, M. Morris Mano, {3rd Edition) (October 19, 1992)
2. Assembly Language Programming for Intel- Computer, 6th Edition, (March 7, 2010)
3. Computer Systems: A Programmer's Perspective, Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University, 3rd edition. (March 2, 2015)
4. Robert Britton, MIPS Assembly Language Programming, Latest Edition (2004)·

Course Name: **Data Communication and Networking (AI-456)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **None**

Course Introduction:

This course introduces the basic concept of computer network to the students. Network layers, Network models (OSI, TCP/IP) and protocol standards are part of the course.

Course Objectives:

Certain objectives have been set out to ensure that the course achieves its aims. Describe the various components and data communication and computer networking; Differentiate between different types of computer networks; Compare the different network topologies; Describe the mechanism and techniques of encoding; Describe a wireless LAN and Data Link Layer switching, and operations of bridges; Explain the Routing concept; Explain the basic principle of internetworking and its importance; Describe the whole concept/idea behind network security as well as the various network/data security algorithms.

Course Learning Outcomes:

1. Describe the key terminologies and technologies of computer networks
2. Explain the services and functions provided by each layer in the Internet protocol stack
3. Identify various internetworking devices and protocols and their functions in a networking
4. Analyze working and performance of key technologies, algorithms and protocols

Course Outline:

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: (or use any other standard and latest books):

1. Computer Networking: A Top-Down Approach Featuring the Internet by James F. Kurose and Keith W. Ross (7^{th} edition) (April 26, 2016)
2. Computer Networks by Andrew S. Tanenbaum (6^{th} edition) (April 24, 2020)
3. Data and Computer Communications by William Stallings (10^{th} edition) (April 24, 2020)
4. Data Communication and Computer Networks by Behrouz A. Forouzan (5^{th} edition) (February 17, 2012)

Course Name: **Operating Systems (AI-553)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **Data Structures**

Course Introduction:

To help students gain a general understanding of the principles and concepts governing the functions of operating systems and acquaint students with the layered approach that makes design, implementation and operation of the complex OS possible.

Course Objectives

This course has two components: a theory component to teach you the concepts and principles that underlie modern operating systems, and a practice component to relate theoretical principles with operating system implementation. In the theory component, you will learn about processes and processor management, concurrency and synchronization, memory management schemes, file system and secondary storage management, security and protection, etc. The practice component will complement the theory component through programming assignments illustrating the use and implementation of these concepts.

Course Learning Outcomes:

1. Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems
2. Analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues with regard to the core functions
3. Demonstrate the knowledge in applying system software and tools available in modern operating systems.

Course Outline:

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 (or use any other standard and latest books):

1. Operating Systems Concepts by Abraham Silberschatz (10^{th} edition) (May 4, 2018)
2. Modern Operating Systems by Andrew S. Tanenbaum, 5^{th} edition. (October 31, 2022)
3. Operating Systems, Internals and Design Principles by William Stallings, 9^{th} edition. (March 13, 2017)

Course Name: **Design and Analysis of Algorithms (AI-556)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **Data Structures**

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

Design algorithms using different algorithms design techniques i.e. Divide and Conquer, Dynamic Programming, Greedy Algorithms & Backtracking. Analyze Algorithms (estimate upper & lower bounds without coding and running the algorithms) and compare the efficiency of different algorithms for a problem. Implement and test algorithms. Logically think and develop problem solving skills.

Course Learning Outcomes:

1. Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm
2. Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.
3. Determine informally the time and space complexity of simple algorithms
4. List and contrast standard complexity classes
5. Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms
6. Use of the strategies (brute-force, greedy, divide-and- conquer, and dynamic programming) to solve an appropriate problem
7. Solve problems using graph algorithms, including single- source and all-pairs shortest paths, and at least one minimum spanning tree algorithm
8. Trace and/or implement a string-matching algorithm

Course Outline:

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.

Reference Materials (or use any other standard and latest books):

1. Introduction to Algorithms by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, 4th edition. (April 5, 2022)
2. Algorithm Design by Jon Kleinberg, Eva Tardos, new international edition (March 16, 2005)
3. Algorithms by Robert Sedgewick, Kevin Wayne, 4th edition. (March 24, 2011)

Course Name: **Information Security (AI-557)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **None**

Course Introduction:

This course provides a broad overview of the threats to the security of information systems, the responsibilities and basic tools for information security, and the levels of training and expertise needed in organizations to reach and maintain a state of acceptable security. It covers concepts and applications of system and data security. Areas of particular focus include secure network design, implementation and transition issues, and techniques for responding to security breaches.

Course Objectives:

In this course students learn basics of information security, in both management aspect and technical aspect. Students understand various types of security incidents and attacks, and learn methods to prevent, detect and react to incidents and attacks. Students will also learn the basics of application of cryptography which are one of the key technologies to implement security functions.

Course Learning Outcomes:

1. Explain key concepts of information security such as design principles, cryptography, risk management, and ethics
2. Discuss legal, ethical, and professional issues in information security
3. Apply various security and risk management tools for achieving information security and privacy
4. Identify appropriate techniques to tackle and solve problems in the discipline of information security

Course Outline:

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 (or use any other standard and latest books):

1. Computer Security: Principles and Practice by William Stallings (5th edition) (January 1, 2019)
2. Principles of Information Security by M. Whitman and H. Mattord (7th edition)(June 27, 2021)
3. Computer Security by Dieter Gollmann (3rd edition) (February 28, 2011)
4. Computer Security Fundamentals by William Easttom (5th edition) (January 2, 2023)
5. Official (ISC)2 Guide to the CISSP CBK (6th edition) (September 15, 2021)

Course Name: **Final Year (Capstone) Project I / II (AI-655/AI-656)**
Credit Hours: **6 (0+6)**
Contact Hours:
Pre-requisites:

A capstone project is typically a final project that allows students to showcase the knowledge and skills they have gained throughout their academic program and apply them to real-world problems and issues.

Course Name: **Thesis I / II (AI-657/AI-658)**
Credit Hours: **6 (6+0)**
Contact Hours:
Pre-requisites:

BS - Artificial Intelligence Domain Core (18/137) 6 Courses		
Sr. No.	**Course Title**	**Cr. Hrs.**
1	Programming for AI	3
2	Machine Learning	3
3	Artificial Neural Networks & Deep Learning	3
4	Knowledge Representation and Reasoning	3
5	Computer Vision	3
6	Parallel & Distributed Computing	3

Course Name **Programming for AI (AI-551)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
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 (Lisp, Prolog, Python, and R), 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 develop the programming acumen and style. The aim of this course is to help students in using the AI programming languages to solve problems of interest to them.

Course Objectives
To study the applications of AI and agent-based approach to AI. To study first-order predicate calculus, logical reasoning and problem-solving using Prolog language. To study and discuss various techniques and algorithms of AI used in general problem solving, optimization problems, constraint satisfaction problems, and game programming. To familiarize students with various sub-areas of AI, such as expert systems, natural language is processing and machine learning.

Course Learning Outcomes:
1. Understand the fundamental constructs of Lisp, Prolog, and Python programming languages
2. Comprehend the fundamental constructs of programming languages for data analysis and representation
3. Understand and apply the Object-oriented concepts in the programming languages
4. Apply various libraries for plotting, interpreting and analyzing data in Python

Course Outline:
Introduction of AI and its applications. AI application development pipeline. AI programming languages. The basics include IDE for the languages, variables, expressions, operands and operators, loops, control structures, debugging, error messages, functions, strings, lists, object-oriented constructs and basic graphics in the languages. Special emphasis is given to writing production quality clean code in the programming language. Once the classical programming languages are 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

Reference Materials:

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", 4th ed, Prentice Hall. (May 8, 2020)
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1st Edition(October 15, 1991)
3. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. 6th Edition.(August 25, 2008)
4. Severance, C.R., 3rd Edition, : Exploring data using Python 3." CreateSpace Independent Publ Platform. (April 9, 2016)
5. Miller, B.N., Ranum, D.L. and Anderson, J., "Python programming in context." Jones & Bartlett Pub. 3rd Edition. (October 15, 2019).
6. McKinney, W., "Python for data analysis: Data wrangling with Pandas, NumPy, and IPython." O'Reilly Media, Inc. 2nd Edition. (November 14, 2017).
7. Joshi, P., "Artificial intelligence with python." Packt Publishing Ltd. 2nd Edition. (January 26, 2017)
8. Janert, P.K., "Data analysis with open source tools: a hands-on guide for programmers and data scientists." O'Reilly Media, Inc. 1st Edition. (December 28 2010)

Course Name	**Artificial Neural Networks & Deep Learning (AI-552)**
Credit Hours	**3 (2+3)**
Contact Hours	**2-3**
Pre-requisites	**Programming for Artificial Intelligence**

Course Introduction:

This course will introduce Artificial Neural Networks and Deep Learning. ANN's basic architecture and how they mimic the human brain using simple mathematical models. Many of the important concepts and techniques around brain computing and the major types of ANN will also be introduced. Emphasis is made on the mathematical models, understanding learning laws, selecting activation functions and how to train the networks to solve classification problems. Deep neural networks have achieved state of the art performance on several computer vision and speech recognition benchmarks. This course will further build on the fundamentals of Neural networks and artificial intelligence and will introduce advanced topics in neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning.

Course objectives:

The overall aim of the course is to give students a basic knowledge of artificial neural networks and deep learning, both theoretical knowledge and how to practically use them for typical problems in machine learning and data mining.

Course Learning Outcomes:

1. Understand the fundamentals of neural networks in AI
2. Explain how simple ANNs can be designed
3. Apply ANN for classification Problems
4. Apply deep learning algorithms to real-world problems
5. Analyze results from deep learning to select appropriate solutions

Course Outline:
Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification. Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Selected topics from: 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; Theory of Generalization; Multi-layer perceptrons, error backpropagation; 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. Neural Network Design, , Martin T. Hagan, Howard, B. Demuth, Mark Hudson Beale and Orlando De Jesus, Publisher: Martin Hagan; 2 edition (September 1, 2014), ISBN-10: 0971732116.
2. An Introduction to Neural Networks, James A Anderson, Publisher: A Bradford Book , ISBN-10: 0262011441 Latest Edition**.(March 16, 1995).**
3. Fundamentals of Artificial Neural Networks, Mohammad Hassoun, Publisher: A Bradford Book , ISBN-10: 0262514672, 1st Edition. (January 1, 2003).
4. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville (http://www.deeplearningbook.org/) (18 November 2016).
5. Deep learning with python by Francoise Chollet, ISBN-10: 9781617294433, 2nd Edition. (December 21, 2021)

Course Name **Machine Learning (AI-555)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites **Artificial Intelligence**

Course Introduction:
Machine learning is one of the fastest growing areas of computer science, with far-reaching applications. The aim of this course is to: a) Present the basic machine learning concepts; b) Present a range of machine learning algorithms along with their strengths and weaknesses; c) Apply machine learning algorithms to solve problems of moderate complexity.

Course objectives:
Learn how computers can learn from experience. Learn and apply statistical techniques for classification and measuring their accuracy. Apply supervised learning techniques for classification. Apply un-supervised learning techniques for classification.

Course Learning Outcomes:
1. Describe basic machine learning concepts, theories and applications.
2. Apply supervised learning techniques to solve classification problems of moderate complexity.

3. Apply unsupervised learning techniques to solve clustering problems of moderate complexity
4. Apply reinforcement learning algorithms to environments with complex dynamics.
5. Develop a reasonable size project using suitable machine learning technique

Course Outline:
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 Aglomerative 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. The Elements of Statistical Learning: Data mining, Inference, and Prediction, by Hastie, Tibshirani, Friedman, 2nd edition. (February 9, 2009)
2. Machine Learning, Tom, M., McGraw Hill, 1st edition.(March 1, 1997)
3. Pattern Recognition and Machine Learning, Christopher M. Bishop, latest edition. (August 17, 2006)
4. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press (August 24, 2012)

Course Name **Computer Vision (AI-651)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites **Artificial Neural Networks & Deep Learning**

Course Introduction:
With a single glance a human interprets the entire scene. How many objects are present in the scene and where they are located. Which person is present in the scene. What will happen next. However, computers lack this capability. We have seen only face detectors so far working in our mobile phones? What is the challenge in understanding the 3D scene, i.e., the identity, the location and the size of the objects present in the scene. In this course we will introduce the basic concepts related to 3D scene modeling from single view and multiple views.

Course objectives:
Identify, formulate and solve problems in image processing and computer vision. Analyse, evaluate and examine existing practical computer vision systems. Communicate effectively and work in teams to develop a working computer vision system.

Course Learning Outcomes:
1. Understanding the single view geometry concepts
2. Understanding the multiple view geometry concepts
3. Apply concepts of CV for solving real world problems

Course Outline:
Introduction to Computer Vision (Problems faced, History and Modern Advancements).

Image Processing, Image filtering, Image pyramids and Fourier transform, Hough transform. Camera models, Setting up a camera model from parameters, Camera looking at a plane, Relationship of plane and horizon line, Rotation about camera center. Concatenation, Decomposition and Estimation of transformation from point correspondences, Points and planes in 2D/3D, Transformations in 2D/3D, Rotations in 2D/3D. Edge detection, corner detection. Feature descriptors and matching (HoG features, SIFT, SURF). Applications of Computer Vision Traditional Methods: Image Stitching: Making a bigger picture from smaller pictures Single View Geometry: Converting a single image into a 3D model. Applications of CV using Deep Learning: Image Detection (Localization, Historical Techniques, RCNN, FRCNN, YOLO, Retina), Image Segmentation (UNet, SegNet, MaskRCNN), Image Generation (GANN

Reference Materials:

1. Computer Vision: Algorithms and Applications, by Richard Szeliski. 2nd edition. (October 19, 2010).
2. Multiple View Geometry in Computer Vision, by Richard Hartley and Andrew Zisserman. 2nd edition.(April 19, 2004).
3. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce. 2nd edition. (October 26, 2011).
4. Digital Image Processing, by Rafael Gonzalez and Richard Woods. 3rd edition. (August 31, 2007)

Course Name: **Parallel and Distributed Computing (AI-652)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **Object Oriented Programming, Operating Systems**
Course Introduction:
Parallel and Distributed Computing is an advance level programming course that helps to analyze sequential algorithms for possible modifications and implementation on available advance machines. This course will cover the study of various parallel and distributed computing hardware, operating system, algorithm design and implementation techniques in detail.

Course objectives:
Learn about parallel and distributed computers– Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library– Analytical modeling and performance of parallel programs– Analyze complex problems with shared memory programming with OpenMP

Course Learning Outcomes:

1. Learn about parallel and distributed computers.
2. Write portable programs for parallel or distributed-architectures using Message-Passing Interface (MPI) Library
3. Analyze complex problems with shared memory-programming with openMP

Course Outline:
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. 4th edition. (February 26, 2016)
2. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K Hwang, J Dongarra and GC. C. Fox, Elsevier. 1st edition. (October 31, 2011)

Course Name **Knowledge Representation and Reasoning (AI-654)**
Credit Hours **3 (3+0)**
Contact Hours **3-0**
Pre-requisites **Artificial Intelligence**

Course Introduction:

Knowledge representation is one of the fundamental areas of Artificial Intelligence. It is the study of how knowledge about the world can be represented and manipulated in an automated way to enable agents to make intelligent decisions. This course will provide an overview of existing knowledge representation frameworks developed within AI including but not limited to propositional and first-order logic, ontologies, planning, reasoning and decision making under uncertainty. The assignments component of the course would provide hands-on experience of software like Prolog, Protégé, probabilistic reasoning APIs and tools to support complex decision making. It is expected that after completing this course, students will understand (a) the foundations of Knowledge Representation & Reasoning and (b) which tools and techniques are appropriate for which tasks.

Course objectives:

The main objective of the course is to provide the students with basic understanding of (logic-based) knowledge representation and reasoning. The course presents important knowledge representation languages, their use and limitations, and techniques and tools for reasoning over them.

Course Learning Outcomes:

1. Understand the fundamentals of knowledge representation and reasoning in deterministic situations
2. Understand the challenges in representing knowledge and reasoning under uncertainty
3. Analyze different situations and apply appropriate knowledge representation frameworks
4. Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems.

Course Outline:

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. Handbook of Knowledge Representation. Frank van Harmelen, Vladimir Lifschitz and Bruce Porter (Eds). Foundations of Artificial Intelligence, 1st edition.(January 22, 2008)
2. Stuard Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th US Edition. (May 8, 2020).

3. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 2023, 3rd Edition(September 21, 2023).
4. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning, 1st edition. (June 11, 2004)

BS - Artificial Intelligence Domain Elective (21/137) 7 Courses

Course Code	Domain Elective 1 & 2	Credit Hrs.
AI-471	Theory of Automata	3 (3+0)
AI-472	Numerical Analysis and Computing	3 (3+0)
AI-473	Simulation and Modeling	3 (3+0)

Course Code	Domain Elective 3, 4	Credit Hrs.
AI-571	Operations Research	3 (3+0)
AI-572	Agent Based Simulation Modeling	3 (3+0)
AI-573	Fuzzy Systems	3 (3+0)
AI-574	Reinforcement Learning	3 (2+1)
AI-575	Social Network Analysis	3 (2+1)
AI-576	Mobile Applications Development	3 (2+1)
AI-577	HCI & Computer Graphics	3 (2+1)

Course Code	Domain Elective 5, 6, 7	Credit Hrs.
AI-671	Natural Language Processing	3 (3+0)
AI-672	Speech Processing	3 (3+0)
AI-673	Swarm Intelligence	3 (3+0)
AI-674	Data Warehousing and Data Mining	3 (2+1)
AI-675	Cyber Security	3 (2+1)
AI-676	Web Engineering	3 (2+1)
AI-677	Bioinformatics	3 (3+0)
AI-678	Complex Networks	3 (3+0)

Course Name: **Theory of Automata (AI-471)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:
This course delves into the mathematical foundations of computation, focusing on abstract machines and formal languages that define the principles of what can be computed and how. You will explore various types of automata, including finite automata, pushdown automata, and Turing machines, as well as the formal languages they recognize or generate. We'll examine concepts such as regular languages, context-free languages, and the limits of computational power. By understanding these fundamental models and their limitations, you'll gain insights into the underpinnings of programming languages, algorithms, and the broader field of computer science. This course is both theoretical and practical, equipping you with tools that are essential for tackling complex computational problems.

Course Objectives:
To familiarize the students with the concept of formal languages, different classes of formal languages such as regular languages, context-free languages, context-sensitive languages, recursive and recursively enumerable languages. To familiarize students with the grammars and machines used for describing various types of languages. These include regular expressions, finite state automata, context-free grammars, push-down automata and Turing machines. To familiarize students with properties of different types of languages.

Course Learning Outcomes:
1. Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc.
2. Prove properties of languages, grammars and automata with rigorously formal mathematical methods
3. Design of automata, RE and CFG
4. Transform between equivalent NFAs, DFAs and Res
5. Define Turing machines performing simple tasks
6. Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.
7.

Course Outline:
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: CFGs, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Reference Materials (or use any other standard and latest books):
1. Introduction to computer theory, Daniel I. A. Cohen. 2nd edition. (October 25, 1996)
2. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich (September 28, 2007)
3. An Introduction to Formal Languages and Automata, by Peter Linz, Jones & Bartlett Publishers, 3rd edition. (October 1, 2000)
4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Kavier, New Age Publishers. Latest edition. (December 1, 2008)

Course Name: **Numerical Analysis and Computing (AI-472)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **Calculus and Analytical Geometry**

Course Introduction:

In this course, you will explore the essential techniques for solving mathematical problems using numerical methods and computing tools. You'll learn how to analyze algorithms, approximate solutions, and assess error, all while gaining practical experience with programming languages commonly used in numerical analysis. Designed for students with a foundational understanding of mathematics, this course will equip you with the skills to tackle complex computational problems across various scientific and engineering disciplines. Join us to enhance your problem-solving abilities and delve into the world of numerical analysis!

Course Objectives:

The overall goal of the field of numerical analysis is the design and analysis of techniques to give approximate but accurate solutions to a wide variety of hard problems, many of which are infeasible to solve symbolically: Advanced numerical methods are essential in making numerical weather prediction feasible.

Course Learning Outcomes:

1. The student would understand the fundamental concepts of Scientific Programming using programing Language(s)
2. Use a computer algebra system to investigate and solve mathematical problems relating to integration, differential equations and approximation

Course Outline:

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

Reference Materials:

1. Numerical Analysis by Richard L. Burden, J. Douglas Faires by Brooks/Cole Boston USA. 9th edition. (2011)
2. Numerical Methods for Scientific Computing by J.H. Heinbockel Trafford Publishing USA (September 10, 2007)

Course Name **Simulation and Modeling (AI-473)**
Credit Hours **3 (3+0)**
Contact Hours **3**
Pre-requisites

Course Introduction:

The course will introduce the basic concepts of computation through modeling and simulation that are increasingly being used by architects, planners, and engineers to shorten design cycles, innovate new products, and evaluate designs and simulate the impacts of alternative approaches. Students will use MATLAB to explore a range of programming and modeling concepts while acquiring those skills. They will then undertake a final project that analyzes one of a variety of scientific problems by designing a representative model, implementing the model, completing a verification and validation process of the model, reporting on the model in oral and written form, and changing the model to reflect corrections, improvements and enhancements.

Course Objectives:

The course will introduce the basic concepts of computation through modeling and simulation that are increasingly being used by architects, planners, and engineers to shorten design cycles, innovate new products, and evaluate designs and simulate the impacts of alternative approaches. Students will use MATLAB to explore a range of programming and modeling concepts while acquiring those skills. They will then undertake a final project that analyzes one of a variety of scientific problems by designing a representative model, implementing the model, completing a verification and validation process of the model, reporting on the model in oral and written form, and changing the model to reflect corrections, improvements and enhancements.

Course Learning Outcomes:

1. Explain the model classification at different levels
2. Analyze complex engineering systems and associated issues (using systems thinking and modeling techniques)
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.
4. Analyze the simulation results of a medium sized engineering problem

Course Outline:

Introduction to Simulation and Modeling, Discrete-Event Simulation, Simulation of a Single-Server Queueing System, Alternative Approaches to Modeling and Simulations; Review of Basic Probability and Statistics; Estimation of Means, Variances, and Correlations, Confidence Intervals and Hypothesis Tests for the Mean, The Laws of Large Numbers; Random number generators; Simulation of discrete, continuous probability distributions and empirical distributions; tests on simulated distributions, rejection method, simulation of multivariate distributions, correlations, and stochastic processes, simulation of models of arrival processes, Poisson Processes, Nonstationary Poisson Processes, Batch Arrivals, tests on generators, Markov- Chain Monte-Carlo simulations; Variance-Reduction Techniques.

Reference Materials:

1. Simulation Modelling and Analysis, A.M. Law and W.D. Kelton, McGraw Hill, 5th Edition. (January 22, 2014)
2. Discrete-event System Simulation, J. Banks, J.S. Carson and B.L. Nelson, Prentice Hall

International, 4th Edition. (January 1, 2004)
3. Probabilistic Modelling, Mitrani, Cambridge University Press, 2nd Edition. (12 Jan. 2008)
4. Simulation and Modelling, Sheldon M. Ross, 6th Edition. (November 20, 2022)
5. Stochastic Simulations, Brian Ripley. Latest Edition.(March 10, 2006)

Course Name **Operations Research (AI-571)**
Credit Hours **3 (3+0)**
Contact Hours **3**
Pre-requisites
Course Introduction:
Operations Research (also called Management Science) is the study of scientific approaches to decision-making. Through mathematical modeling, it seeks to design, improve and operate complex systems in the best possible way. The mathematical tools used for the solution of such models are either deterministic or stochastic. Students will learn very powerful modeling and solution techniques for decision-making problems that are used today by many successful companies to help them save/earn millions of dollars.

Course Objectives:
The aim of this course is to further intimate you with operations research, acquaint you with the mathematical calculations and the practical approximation of the idealised theorems which allows you establish their practicable applications and indispensability in the real world. You should also bear in mind the practical limitations of the concepts idealised in the real world. You are required to conscientiously and diligently work through this course and upon completion of this course, you should be able to:
understand the meaning of operations research; highlight the historical development of operations research; describe the scientific nature of operations research; identify the importance and uses of operations research with respect to the various topics to be treated in the study; state the limitations of operations research; state the meaning of model in operations research; describe the various types of model; describe how to construct a model; list some standard operations research model; state the usefulness of linear programming in operations research; state the properties of a linear programming model; identify some areas of application of linear programming; formulate a linear programming model; state the usual assumptions of a linear programming model; solve a two-variable linear programming model graphically; prepare LPD for use of simplex; explain the use of simplex.

Course Learning Outcomes:
1. To introduce the students how to use variables for formulating complex mathematical models in management science, industrial engineering and transportation science.
2. To provide the students with opportunity of using various software package for solving linear programming and integer programming models.
3. To introduce the students to the use of basic methodology for the solution of linear programs and integer programs.
4. To introduce the students to the basic concepts of polyhedral theory and valid inequalities and how to integrate the theory to the solution methods for integer programming.
5. To introduce the students to the advanced methods for large-scale transportation and assignment problems.

Course Outline:
Introduction to mathematical modeling. Linear program models, simplex method for solving LP models, sensitivity analysis, other solution techniques for LP models, specialized LP models (transport, assignment, etc.). Network based models, shortest path, min weight spanning tree, max flow, PERT/CPM. Decision models, dynamic programming, games

theory. Probabilistic models, expected return models, Markov chains, stochastic processes, queuing models, stochastic inventory models.
Given a scenario, select and develop an appropriate model, solve it for the given parameters, and analyze the sensitivity of the solution to changes in the problem parameters

Reference Materials:
1. Operations Research: An Introduction, Hamdi A. Taha, 10th Edition (January 1, 2019)
2. Introduction to Operations Research, F.S. Hillier, and G. J. Leibermann, (8/e), Latest Edition (not found)
3. W. Winston, Operations Research, Duxbury Press. Operations Research: Applications and Algorithms, Wayne L Winston, 2014 or Latest Edition. Edition (not found)

Course Name **Agent Based Simulation Modeling (AI-572)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites
Course Introduction:
Agent-based modeling and simulation provides a systematic way to explore macroscopic behaviors of the complex system (e.g., behavior patterns) that derived from microscopic modeling mechanisms (e.g., individual characteristics and behaviors). In this course, we will learn fundamental concepts of the agent-based modeling and gain hands-on experiences of using simulation toolkit AnyLogic® to model and simulate real-world complex systems. Through the course, we will introduce a series of essential topics including, but not limited to, when agent-based models are most appropriate to employ, what is agent-based modeling, how to conceptualize and formulize agent-based models, and how to implement the computer simulation model in AnyLogic. To achieve all this, we will have detailed discussions on several relevant examples and papers that cover various application areas (e.g., health care, supply-chain, manufacturing, etc.).

Course Objectives
Simulation modeling solves real-world problems safely and efficiently. It provides an important method of analysis which is easily verified, communicated, and understood. Across industries and disciplines, simulation modeling provides valuable solutions by giving clear insights into complex systems.

Course Learning Outcomes:
1. be familiar with the design concepts of agent-based modeling
2. be able to create your own agent-based models
3. be proficient with AnyLogic

Course Outline:
The course will cover topics to answer why is agent-based modeling an effective approach to model complex systems? What is agent-based modeling? How to create your own agent-based models? What are the basic components of agent-based models? How to select and assign model parameters of an agent-based model? How to construct the agent-based model in AnyLogic? How to analyze the result of an agent-based model?

Reference Materials:
1. An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo (Mit Press), (2015)
2. Agent-Based Modeling and Simulation with Swarm, Chapman and Hall/CRC (Nov 2016).

Course Name **Fuzzy Systems (AI-573)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites
Course Introduction:
The course is designed to give a solid grounding of fundamental concepts of fuzzy logic and its applications. The level of the course is chosen to be such that all students aspiring to be a part of computational intelligence directly or indirectly in near future should get these concepts.

Course Objectives
The main objectives of this course are to: Introduce students to the various neural network and fuzzy systems models. Applications, including Back-propagation, BAM, Hopfield network, Competitive Learning, ART, SOFM, Fuzzy inference methods and expert systems. learning rules for each of the architectures.

Course Learning Outcomes:
Understand Fuzzy Logic Principles: Explain the fundamental concepts of fuzzy logic and its differences from traditional binary logic. **Design Fuzzy Systems**: Create and implement fuzzy inference systems and rule-based models. **Apply Fuzzy Control Techniques**: Develop fuzzy controllers for managing complex systems with uncertainty.

Course Outline:
Introduction, Uncertainty, Imprecision and Vagueness, Fuzzy systems, Brief history of Fuzzy logic, Foundation of Fuzzy Theory, Fuzzy Sets and Systems, Fuzzy Systems in Commercial Products, Research Fields in Fuzzy Theory, Classical sets and Fuzzy sets, Classical Relations, Fuzzy relations, Membership Functions, Fuzzy to crisp conversions, Fuzzy arithmetic, Numbers, Vectors and the extension principle, Classical logic and Fuzzy logic, Mathematical background of Fuzzy Systems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Types of Membership Functions, Basic Concepts (support, singleton, height, a cut projections), Fuzzy set operations, Sand T Norms, Properties of Fuzzy sets, Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations, Examples, Linguistic variables and hedges, Membership function design. Basic Principles of Inference in Fuzzy Logic, Fuzzy IFTHEN Rules, Canonical Form, Fuzzy Systems and Algorithms, Approximate Reasoning, Forms of Fuzzy Implication, Fuzzy Inference Engines, Graphical Techniques of Inference, Fuzzifications/Defuzzification, Fuzzy System Design and its Elements, Design options. Fuzzy Events, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs, Probability, Fuzzy Systems as Universal Approximations, Additive Fuzzy Systems (standard additive model).

Reference Materials:

1. Introduction to Fuzzy Systems By Guanrong Chen, Trung Tat PhamCopyright 2006.
2. An Introduction to Many-Valued and Fuzzy Logic: Semantics, Algebras, and Derivation Systems by Merrie Bergmann | Jan 14, 2008

Course Name **Reinforcement Learning (AI-574)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites

Course Introduction:
To realize the dreams and impact of AI requires autonomous systems that learn to make good decisions. Reinforcement learning is one powerful paradigm for doing so, and it is relevant to an enormous range of tasks, including robotics, game playing, consumer modeling and healthcare. This class will provide a solid introduction to the field of reinforcement learning and students will learn about the core challenges and approaches, including generalization and exploration. Through a combination of lectures, and written and coding assignments, students will become well versed in key ideas and techniques for RL. Assignments will include the basics of reinforcement learning as well as deep reinforcement learning — an extremely promising new area that combines deep learning techniques with reinforcement learning.

Course Objectives
Learn how to define RL tasks and the core principals behind the RL, including policies, value functions, deriving Bellman equations. Implement in code common algorithms following code standards and libraries used in RL. Understand and work with tabular methods to solve classical control problems. Understand and work with approximate solutions (deep Q network based algorithms). Learn the policy gradient methods from vanilla to more complex cases • Explore imitation learning tasks and solutions. Recognize current advanced techniques and applications in RL.

Course Learning Outcomes:
1. Define the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning
2. Given an application problem (e.g. from computer vision, robotics, etc), decide if it should be formulated as a RL problem; if yes be able to define it formally (in terms of the state space, action space, dynamics and reward model), state what algorithm (from class) is best suited for addressing it and justify your answer
3. Describe the exploration vs exploitation challenge and compare and contrast at least two approaches for addressing this challenge (in terms of performance, scalability, complexity of implementation, and theoretical guarantees)

Course Outline:
Learning and its types, Introduction to Reinforcement learning, Reinforcement learning task formulation (action space, state space, environment definition). Reinforcement learning environments. Multi-agent reinforcement learning. Imitation learning (behavioral cloning). Meta-learning. Introduction to Reinforcement Learning, Tabular MDP planning, Tabular RL policy evaluation, Q learning and Function approximation, Function approximation, Policy Search, Policy Search, Exploration / exploitation, Imitation Learning, Value Alignment.

Reference Materials:
1. Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition. (November 13, 2018).
2. Reinforcement Learning: State-of-the-Art, Marco Wiering and Martijn van Otterlo, (2012).
3. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, 4th edition. (May 8, 2020)

Course Name **Social Network Analysis (AI-575)**
Credit Hours **3 (2+3)**
Contact Hours **2-3**
Pre-requisites
Course Introduction:
Who is key in a group? How fast can a message spread on Facebook? Are you really six degrees away from a random stranger? Learn how to answers these questions in 08201. Social Network Analysis (SNA) has become a widely applied method in research and business for inquiring the web of relationships on the individual, organizational and societal level. With ready access to computing power, the popularity of social networking websites such as Facebook, and automated data collection techniques the demand for solid expertise in SNA has recently exploded. In this course, students learn how to conduct SNA projects and how to approach SNA with theoretic, methodological, and computational rigor. This interdisciplinary, undergraduate-level course introduces students to the basic concepts and analysis techniques in SNA. Students learn how to identify key individuals and groups in social systems, to detect and generate fundamental network structures, and to model growth and diffusion processes in networks. Students will be trained in interpreting the meaning of the aforementioned phenomena and suggesting potential courses of action to reinforce or change the observed trends. After this course, students will be able to design and execute network analysis projects including collecting data and considering ethical and legal implications, to perform systematic and informed analyses of network data for personal, commercial and scholarly use, and to critically review SNA projects conducted by others

Course objectives
Social network analysis is a research method that can be applied to the study of human social interactions. It is used in a variety of fields, including psychology and sociology. The purpose of SNA is to provide an analytical framework for understanding how people interact with one another within a network.

Course Learning Outcomes:
1. Formalize different types of entities and relationships as nodes and edges and represent this information as relational data.
2. Plan and execute network analytical computations.
3. Use advanced network analysis software to generate visualizations and perform empirical investigations of network data.
4. Interpret and synthesize the meaning of the results with respect to a question, goal, or task.
5. Collect network data in different ways and from different sources while adhering to legal standards and ethics standards.

Course Outline:
Overview on Network Analysis, The Network Analysis Process and Methodology, Network Visualization, When images do not suffice: Network analytical measures, Models and Simulation of Network Evolution, Models and Simulation of Diffusion in Networks, Subgroups and Cliques, Clustering, Block models, Ego networks, Reciprocity, Social capital, structural holes, equivalence, Manual and ethnographic methods, automated methods, Cognitive Social Structures, Introduction: Integration of text and network analysis, Types of networks extracted from texts across disciplines, Natural Language Processing and (Computational) Linguistics for Information and Relation Extraction, Work on your project, discuss your project update and any problems with the class and the instructors, Introduction: Multi-agent models for representing networks,

Reference Materials:

1. Scott, J. Social network analysis: A handbook. Newbury Park, CA: Sage, 2nd edition. (May 2, 2000).
2. Knoke Social Network Analysis (2nd Edition).Sage. (November 14, 2007)

Course Name: **Mobile Application Development (AI-576)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **Object Oriented Programming**

Course Introduction:

This course will guide you through the essentials of creating innovative mobile apps, covering everything from design principles to coding techniques. By the end, you'll be equipped to turn your app ideas into reality and navigate the dynamic mobile landscape.

Course objectives:

Mobile Application Development is market oriented course in the undergraduate programs of Department of Computer Science at Capital University of Science and Technology. Today, mobile applications are used not only as a standalone application but also with most of web or desktop applications. These applications are highly user focused and designed for every walk of life. Moreover, with the growing strength and cheap availability of mobile devices it has emerged as an important tool in both local and international job market. The course is designed to impart both conceptual and practical knowledge, which is accompanied with hands-on training primarily focused on Android OS, Apple iOS and related tools. The course demonstrates standard practices and tools used in market to develop robust mobile applications.

Course Learning Outcomes:

1. Discuss different architectures & framework for Mobile Application development.
2. Develop mobile applications using current software development environments.
3. Compare the different performance tradeoffs in mobile application development.

Course Outline:

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 E- mail; 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.

Reference Materials:

1. Professional Android application development, Reto Meier, Wrox Programmer to Programmer. (2012).
2. iOS Programming: The Big Nerd Ranch Guide, Conway, J., Hillegass, A., & Keur, C.(2010).
3. Android Programming: The Big Nerd Ranch Guides, Phillips, B. & Hardy, B. 3rd edition. (March 31, 2013).

Course Name **HCI & Computer Graphics (AI-577)**
Credit Hours **3 (2+1)**
Contact Hours **2-3**
Pre-requisites **Linear Algebra, Fundamentals of Programming**

Course Introduction:

In this course, students are introduced to the fundamental theories and concepts of human-computer interaction (HCI). HCI is an interdisciplinary field that integrates theories and methodologies across many domains including cognitive psychology, neurocognitive engineering, computer science, human factors, and engineering design. Students will gain theoretical knowledge of and practical experience in the fundamental aspects of human perception, cognition, and learning as relates to the design, implementation, and evaluation of interfaces. Topics covered include: interface design, usability evaluation, universal design, multimodal interfaces (touch, vision, natural language and 3-D audio), virtual reality, and spatial displays. In addition to lectures, students will work on individual and team assignments to design, implement, and evaluate various interactive systems and user interfaces based on knowledge culled from class material and additional research.

Course Objective:

Course introduces the main concepts of designing, evaluating and functional deploying, effectual technologies in a range of circumstance - be it office, home, school, internet world or other domain. The objective of this course is to give an introduction to the key areas, accessing and design developments in the field. The course aims, understanding and importance of UI its design and mistakes. The course helps to learn basics concepts of field such as, design rules and guidelines, prototyping and design patterns for interactive systems

Course Learning Outcomes:

1. Students will learn the basic physiological, perceptual, and cognitive components of human learning and memory.
2. Students will gain theoretical knowledge of and practical experience in the fundamental aspects of designing and implementing user interfaces.
3. Students will learn to analyze interaction problems from a technical, cognitive, and functional perspective.
4. Students will develop an awareness of the range of general human-computer interaction issues that must be considered when designing information systems.
5. Students will learn about multimodal displays for conveying and presenting information.
6. Students will know and have practiced a variety of simple methods for designing and evaluating the quality of user interfaces and spatial displays.

Course Outline:

Human, Computer and Interaction, Usability paradigm and principles, Introduction to design basics, HCI in software process, Design rules, prototyping, evaluation techniques, task analysis, Universal design and User support and Computer Supported Cooperative Work; Introduction to specialized topics such as Groupware, pervasive and ubiquitous applications.
Fundamental algorithms. Applications of graphics. Interactive graphics programming — graph plotting, windows and clipping, and segmentation. Programming raster display systems, Differential Line Algorithm, panning and zooming. Raster algorithms and software — Scan-Converting lines, characters and circles. Scaling, Rotation, Translation, Region filling and clipping. Two and three dimensional imaging geometry (Perspective projection and Orthogonal projection) and transformations. Curve and surface design, rendering, shading, colour and animation.

Reference Materials:

1. "Human-Computer Interaction", Alan Dix, Computing Department, Lancaster University Janet E. Finlay, Leeds Metropolitan University, Gregory D. Abowd, Georgia Institute of Technology, Russell Beale, University of Birmingham, 3rd edition. (September 30, 2003)
2. "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Ben Shneiderman, University of Maryland Catherine Plaisant, University of Maryland. 6th edition. (April 20, 2016)
3. Fundamentals of Computer Graphics: 2nd Edition by Peter Shirley A. K. Peters, 5th edition. (September 30, 2021)

Course Name: **Internet of Things (AI-578)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:

This course introduces the fundamental concepts and technologies driving the Internet of Things (IoT) and explores its relevance to AI. Students will learn how IoT systems interact with the physical world, collect data, and make intelligent decisions using AI models. The course will cover various IoT architectures, protocols, and applications, with an emphasis on how AI enhances IoT capabilities.

Course objectives

The Internet of Things (IoT) is the network of physical objects in which microprocessor and wireless radios are embedded to intelligently serve people in a collaborative manner. In future, IoT is expected to revolutionize many areas of human life i.e., agriculture, healthcare, transportation, manufacturing, engineering etc. This undergraduate course covers the conceptual understanding of IoT fundamentals.

Course learning outcomes:

1. Understand the architecture and core components of IoT systems.
2. Learn various IoT communication protocols and networking techniques.
3. Apply AI techniques for data collection, processing, and decision-making in IoT environments.
4. Explore the security, privacy, and ethical implications of IoT systems.
5. Develop hands-on experience in IoT device programming and deployment.

Course Outline

Basics of Electronic Designs: ADCs/DACs, PVM and Voltage Dividers , SDN Architecture, Control and Management plane improvements with SDN, Openness, Network Automation and Virtualization, SDN and OpenStack, ONOS SDN Controllers, Applications and APIs, Protocols; Arduino and Raspberry Pi Programming; *Introduction to the Internet of Things, IoT and its importance, Elements of an IoT ecosystem, Technology and business drivers, IoT applications, trends and implications; Sensors and sensor nodes, Sensing components and devices, Sensor modules, nodes, motes and systems; Connectivity and networks, Wireless technologies for the IoT. Edge connectivity and protocols, Wireless sensor networks

Reference Materials: (or use any other standard and latest books):

1. Learning Internet of Things by Peter Waher (Author) ISBN 978-1783553532, published by Packt Pub Ltd. (2015).

2. Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry, by Maciej Kranz, ISBN 978-1119285663, published by Wiley, (2016).
3. Internet of Things from Scratch: Build IoT solutions for Industry 4.0 with ESP32, Raspberry Pi, and AWS by Renaldi Gondosubroto, ISBN 978-1837638543, published by Packt Publishing (February 16, 2024)

Course Name	**Natural Language Processing (AI-671)**
Credit Hours	**3 (3+0)**
Contact Hours	**3**
Pre-requisites	**Artificial Neural Networks & Deep Learning**

Course Introduction:
Natural Language Processing (NLP) is the application of computational techniques to the analysis and synthesis of natural language and speech. This course is an introduction to NLP with prior programming experience in Python.

Course Objectives:
This course aims to provide a comprehensive view of building real-world natural language processing (NLP) applications. The diverse applications of NLP are based on a common set of ideas, drawing on algorithms, linguistics, logic, statistics, and more.

Course Learning Outcomes:
1. Understand techniques for information retrieval, language translation, and text classification.
2. Understand the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks
3. Understand and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each
4. Solve classic and stochastic algorithms for parsing natural language

Course Outline:
Introduction & History of NLP, Parsing algorithms, Basic Text Processing, Minimum Edit Distance, Language Modeling, Spelling Correction, Text Classification, Deterministic and stochastic grammars, CFGs, Representing meaning /Semantics, Semantic roles, Semantics and Vector models, Sentiment Analysis, 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, Relation Extraction (dependency, constituency grammar), Language translation, Text classification, categorization, Bag of words model, Question and Answering, Text Summarization

Reference Materials:
1. Daniel Jurafsky and James H. Martin. 2018. Speech and Language Processing: An Introduction to Natural Language Processing. 3rd Edition. Prentice Hall (January 1, 2000).
2. Natural Language Processing A Machine Learning Perspective Yue Zhang Westlake University, Zhiyang Teng Published 2020.

Course Name **Speech Processing (AI-672)**
Credit Hours **3 (3+0)**
Contact Hours **3**
Pre-requisites
Course Introduction:
Speech Processing requires knowledge of digital signal processing at first step, that will be covered in introductory sessions. Speech processing has been one of the main application areas of digital signal processing for several decades now, and as new technologies like voice over IP, automated call centers, voice browsing and biometrics find commercial markets, speech seems set to drive a range of new digital signal processing techniques for some time to come. This course provides not only the technical details of ubiquitous techniques like linear predictive coding, Mel frequency cepstral coefficients, Gaussian mixture models and hidden Markov models, but the rationale behind their application to speech and an understanding of speech as a signal. Contemporary signal processing is almost entirely digital, hence only discrete-time theory is presented in this course.

Course Objectives:
To acquire the fundamentals of the digital signal processing that allows them to assimilate the concepts related to the speech processing. 2. To introduce the fundamentals of speech signal processing. 3. To present basic principles of speech analysis. 4. To give an overview of speech processing applications including speech enhancement, speech recognition and speaker recognition

Course Learning Outcomes:
1. Express the speech signal in terms of its time domain and frequency domain representations and the different ways in which it can be modelled;
2. Derive expressions for simple features used in speech classification applications
3. Explain the operation of example algorithms covered in lectures, and discuss the effects of varying parameter values within these
4. Synthesise block diagrams for speech applications, explain the purpose of the various blocks, and describe in detail algorithms that could be used to implement them
5. Implement components of speech processing systems, including speech recognition and speaker recognition, in MATLAB.
6. Deduce the behaviour of previously unseen speech processing systems and hypothesise about their merits.

Course Outline:
Introduction to speech processing Time-frequency analysis-1, Time-frequency analysis-2, Speech Modeling, Linear Predictive Analysis, Human Auditory System, Speech Enhancement, Clustering and Gaussian Mixture models, Front-end processing, Speaker Recognition, Hidden Markov models, Speech recognition,

Reference Materials:

1. Quatieri, T. F. (3rd Edition). Discrete-Time Speech Signal Processing, Prentice-Hall, New Jersey. (October 29, 2001)
2. Rabiner, L. R., and Juang, B.-H. (1993). Fundamentals of Speech Recognition, Prentice-Hall. (January 1, 1993)
3. Mitra, S. K. (2nd Edition). Digital Signal Processing: A Computer-Based Approach, McGraw-Hill. (January 1, 2001)

Course Name **Swarm Intelligence (AI-673)**
Credit Hours **3 (3+0)**
Contact Hours **3**
Pre-requisites

Course Introduction:

This course is designed to present an overview of Swarm Intelligence (SI) topic, including both behavioral swarm Intelligence and computational swarm intelligence, and applications of SI. The students will learn different swarm intelligence algorithms that are inspired by natural systems such as ant colonies, bird flocking, animal herding, bacterial growth, fish schooling and microbial intelligence. The students will implement different swarm intelligence algorithms, visualize and apply them to solve real problems such as optimization problems.

Course objectives:

Swarm intelligence refers to the study and simulation of the collective behavior of gregarious creatures, such as insects, for the purpose of solving complex problems. It involves the exchange of information between decentralized and self-organized systems, leading to global system behavior.

Course Learning Outcomes:

1. Have knowledge of individual/intelligent agents for modeling of industrial, social and biological systems.
2. Have knowledge of modeling swarms/social agents in complex landscapes.
3. Have knowledge of swarm intelligence algorithms inspired by different natural systems.

Course Outline:

Agent-based modeling: Bottom-up modeling method. individual agents. System theory and complex systems. Multi-agent systems. Behavioral swarm intelligence: Modeling flocking behavior. Boids model. Flocking behavior applications, such as agents queuing and homing. Computational swarm intelligence (CSI): Optimization theory and multi-objective optimization. Particle swarm optimization (PSO) Ant colony optimization (ACO). Bees colony algorithm (BCO). Bats algorithm, Selected applications: Different selected application where the students can apply the swarm intelligence algorithms to solve real problems, such as: Multi-robot path planning and Task scheduling

Reference Materials:

1. Andries P. Engelbrecht, Fundamentals of computational swarm intelligence, Wiley (2015)
2. Anand Nayyar, Dac-Nhuong Le, Nhu Gia Nguyen, Advances in Swarm Intelligence for Optimizing Problems in Computer Science Chapman and Hall/CRC, (2018),
3. James Kenndey and Rusell C. Eberhart, Swarm Intelligence, MKF, ISBN: 978-1-55860-595-4.(2019)
4. Harald Yndestad: Agents and Landscapes as Complex Systems (November 2012)

Course Name **Data Warehousing and Data Mining (AI-674)**
Credit Hours **3 (3+0)**
Contact Hours **3**
Pre-requisites
Course Introduction:
This course gives an introduction to methods and theory for development of data warehouses and data analysis using data mining. Data quality and methods and techniques for preprocessing of data. Modeling and design of data warehouses. Algorithms for classification, clustering and association rule analysis. Practical use of software for data analysis

Course objectives:
Be familiar with mathematical foundations of data mining tools. Understand and implement classical models and algorithms in data warehouses and data mining. Characterize the kinds of patterns that can be discovered by association rule mining, classification and clustering.

Course Learning Outcomes:
1. Data preprocessing and data quality.
2. Modeling and design of data warehouses.
3. Algorithms for data mining Skills:
4. Be able to design data warehouses.
5. Ability to apply acquired knowledge for understanding data and select suitable methods for data analysis.

Course Outline:
Data Warehouse: (a) Data Model for Data Warehouses. (b) Implementing Data Warehouses: data extraction, cleansing, transformation and loading, data cube computation, materialized view selection, OLAP query processing. Data Mining: (a) Fundamentals: data mining process and system architecture, relationship with data warehouse and OLAP systems, data pre-processing. (b) Mining Techniques and Application: association rules, mining spatial databases, mining multimedia databases, web mining, mining sequence and time-series data, text mining, etc. The lecture materials will be complemented by projects /assignments.

Reference Materials:
1. Data Mining and Data Warehousing: Principles and Practical Techniques, june 2019, Cambridge University Press (June 27, 2019)
2. Data Warehousing, Data Mining, and OLAP (Data Warehousing/Data Management), McGraw-Hill (1997)

Course Name: **Cyber Security (AI-675)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites:
Course Introduction:
This course provides a comprehensive introduction to cyber security principles, covering both theoretical foundations and practical applications. Students will explore critical topics such as cryptography, network security, threat analysis, security protocols, and how AI can be leveraged in cyber security defense mechanisms. The course will also address the ethical, legal, and societal implications of cyber security.

Course Objectives:
To prepare students with the technical knowledge and skills needed to protect and defend computer systems and networks. To develop graduates that can plan, implement, and monitor cyber security mechanisms to help ensure the protection of information technology assets. To develop graduates that can identify, analyze, and remediate computer security breaches.

Course Learning Outcomes:
1. Understand fundamental concepts and challenges in cyber security.
2. Explore different types of cyber threats, vulnerabilities, and attack vectors.
3. Implement basic cryptographic techniques and security protocols.
4. Apply AI techniques to enhance cyber security measures, such as intrusion detection systems.
5. Analyze case studies of cyber-attacks and devise mitigation strategies.
6. Understand ethical and legal concerns in cyber security.

Course Outline:
Basic security concepts, Information security terminology, Malware classifications, Types of malwares. Server-side web applications attacks. Cross-site scripting, SQL Injection, Cross item request forgery, Planning and policy, Network protocols and service models. Transport layer security, Network layer security, Wireless security, Cloud & IoT security.

Reference Materials:
1. Security+ Guide to Network Security Fundamentals by Mark Ciampa, 7th edition. (December 16, 2020)
2. Corporate Computer Society by Randall J.Boyle, 5th edition. (May 4, 2020)

Course Name: **Web Engineering (AI-676)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **Programming Fundamentals**

Course Introduction:

Web Engineering focuses on the systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of complex web-based applications. This course provides students with the knowledge and skills necessary for designing, developing, and maintaining scalable and secure web systems. Emphasis will be placed on the integration of Artificial Intelligence techniques into modern web development to create intelligent, responsive, and user-centric web applications.

Course objectives:

This course will address issues associated with large-scale web application development including requirements, architectural design and documentation, server and client-side development technologies, and service-oriented computing technologies. After completion of this course, students will be able to analyze, architect and design comprehensive systems for the creation, dissemination, storage, retrieval, and use of electronic records. To use some of the development languages, frameworks and reusable services in order to manipulate information on the World Wide Web. To learn techniques and evaluation metrics for ensuring the proper operability, maintenance and security of a web application.

Course Learning Outcomes:

1. Discuss how web standards impact software development.
2. Describe the constraints that the web puts on developers.
3. Design and implement a simple web application.
4. Review an existing web application against a current web standard.

Course Outline:

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.

Reference Materials:

1. Web Engineering, Rajiv Chopra, (2016).
2. Web Engineering, Emilia Mendes and Nile Mosley, (2006)
3. Web Engineering: A Practitioners' Approach, Roger S. Pressman, (2009.)
4. Dynamic HTML: The Definitive Reference: A Comprehensive Resource for XHTML, CSS, DOM, JavaScript(January 30, 2007)
5. JavaScript: The Definitive Guide, David Flanagan, 6th edition.(June 7, 2011)

Course Name: **Bioinformatics (AI-677)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course introduction:
Bioinformatics combines biology, computer science, and information technology to analyze and interpret biological data. This course introduces students to the key concepts, tools, and techniques used in the field of bioinformatics, focusing on the application of Artificial Intelligence to solve biological problems. Topics covered include DNA and protein sequence analysis, structural bioinformatics, genomics, and bioinformatics databases.

Course objectives:
This course introduces bioinformatics concepts and practice. Topics include: biological databases, sequence alignment, gene and protein structure prediction, molecular phylogenetic, genomics and proteomics.

Course learning outcomes:
1. Understand the biological foundations necessary for bioinformatics.
2. Analyze DNA, RNA, and protein sequences using computational tools.
3. Apply algorithms and AI techniques for biological data analysis.
4. Explore bioinformatics databases and understand their use in research.
5. Use machine learning for predicting biological structures and functions.
6. Solve real-world problems in genomics, proteomics, and other biological domains.

Course outline:
Course Outline Introduction, history, timeline, databases, sequence storage, retrieval and analysis, similarity and homology, creating alignments, local and global alignment, pairwise and multiple sequence alignments, phylogenetic analysis, dot matrix plots, dynamic programming algorithm, word (k-tuple) methods, substitution matrices PAM and BLOSUM, scoring algorithms, gap penalties, online tools BLAST, BLAT and FASTA, PDB file structure. Lab Outline Accessing NCBI, ENSEMBL, UniProt , Genbank, EMBL, SWISS-PROT, Accessing structural databases including PDB, SCOP and CATH, EXPASY and FASTA using tools for pairwise and multiple sequence alignment, Phylogenetic analysis, Bioedit.

Reference Materials: (or use any other standard and latest books):

1. Arthur M. Lesk, “Introduction to Bioinformatics”, Oxford University Press. (5th edition) (July 21, 2019).
2. Ignacimuthu SJ, “Basic Bioinformatics”, Narosa Publishing House. (2nd edition)(1 January 2013).
3. Yadav Neelam, “A Hand Book of Bioinformatics”, Anmol Publications Pvt.Ltd. (2004).
4. Krawetz. Stephen A., “Introduction to Bioinformatics: A Theoretical and Practical Approach”, Humana Press. (2003)

Course Name: **Complex Networks (AI-678)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**
Course introduction:
In this course, you will delve into the fascinating world of complex systems and the intricate networks that define them. You'll explore fundamental concepts such as graph theory, network topology, and dynamics, while examining real-world applications in areas like social networks, biological systems, and transportation. Designed for students with a background in mathematics or computer science, this course will equip you with the analytical tools to understand and analyze complex interactions within various networks. Join us to uncover the patterns and principles that govern the behavior of interconnected systems!

Course objectives:
The objectives of the Complex Networks course are to provide you with a solid understanding of the fundamental principles of network theory and its applications. You will explore graph theory, analyze network properties, and model network dynamics. The course aims to equip you with the skills to assess vulnerabilities in complex networks and enhance their resilience. Additionally, you will gain practical experience using analytical tools for network visualization and analysis, while applying your knowledge to real-world scenarios across various fields, such as sociology, biology, and technology.

Course learning outcomes:
1. **Understand Key Concepts**: Explain fundamental concepts in complex networks, including graph theory, nodes, edges, and network topology.
2. **Analyze Network Structures**: Analyze various types of networks, such as social, biological, and technological networks, and identify their structural properties.
3. **Model Complex Systems**: Develop and apply mathematical models to simulate the behavior of complex networks.
4. **Identify Network Dynamics**: Explore the dynamics of network evolution, including growth patterns, clustering, and community detection.
5. **Evaluate Network Resilience**: Assess the robustness and vulnerability of networks to failures and attacks.

Course outline:
Empirical Studies of networks, Biological Networks, Social Networks, Technological Networks, Fundamentals of Network Theory: Mathematics of Networks, Types of Graphs, Hypergraphs, weighted and directed graphs, trees, degree, paths components; Centrality Measures and Metrics, Node and link centrality, degree centrality, hubs, closeness and betweenness centrality, paths and network diameter; Structural Properties of Networks, Community structures, components, statistical properties, degree distributions, network motifs, network resilience to attacks and failure; Types of networks, Scale free networks, small-world networks, random networks, ER-Networks, Models for network generation and growth, Network algorithms, analysis, network generation, community detection, Network visualization algorithms, Dynamical processes on networks.

Reference Materials: (or use any other standard and latest books):
1. Networks, An Introduction by Marc Newman, Oxford University Press ISBN: 9780199206650, (2010).

2. Complex Networks: Principles, Methods and Applications, by Vito Latora, Vincenzo Nicosia and Giovanni Russo (Author), ISBN **978-1107103184,** published by **Cambridge University Press, (2017).**
3. Complex Networks by Kayhan Erciyes, ISBN: 9781466571679 Publisher(s): CRC Press, (2014).

BS - Artificial Intelligence Mathematics & Supporting Courses (12/137) 4 Courses		
Course Code	**Course Title**	**Cr. Hrs.**
AI-457	Multivariable Calculus	3
AI-356	Linear Algebra	3
AI-459	Probability & Statistics	3
AI-558	Technical and Business Writing	3

Course Name **Multivariable Calculus (AI-457)**
Credit Hours **3 (3+0)**
Contact Hours **3-0**
Pre-requisites
Course Introduction:
Multivariate calculus uses linear algebra to extend the important concepts of single-variable calculus to higher-dimensional settings. Topics include scalar-valued and vector-valued functions, graphs, level sets, limits and continuity; partial derivatives, gradients, tangent planes, differentiability, total derivatives, directional derivatives; paths, velocity, acceleration, arclength, curvature, vector fields, divergence, curl; extrema, Hessians, Lagrange multipliers; multiple integrals, change of variables, Jacobians; line integrals, Green's theorem; surface integrals, Stokes' theorem, and Gauss' theorem

Course objectives:
The course objective is that its successful completion should develop understanding of multivariable functions, partial differentiation and multiple integrals. The applications will be covered from several engineering problems. The other objective is to learn basic vector differential operators, gradient, divergence and curl along with their applications to calculate surface integrals, flows, flux across surfaces, Fourier series and transforms.

Course Learning Outcomes:
1. To provide students with a good understanding of the concepts and methods of multivariate calculus, described in detail in the syllabus.
2. To help the students develop the ability to solve problems using multivariate calculus.
3. To connect multivariate calculus to other fields both within and without mathematics.
4. To develop abstract and critical reasoning by studying proofs as applied to multivariate calculus

Course Outline:
Parametric equations ,Polar coordinates ,Polar coordinates ,Vectors, dot product ,dot product, determinant, cross product ,Equations of lines and planes, quadrics ,vector functions, derivatives ,Functions of several variables, limits, continuity ,Partial derivatives, tangent planes ,Chain rule ,Gradient, directional derivative, Max-min problems ,Lagrange mulitpliers ,Double integrals ,Double integrals in polar coordinates and applications ,Surface area

,Change of variables in double integrals ,Triple integrals ,Triple integrals in spherical coordinates ,Vector fields and line integrals ,Gradient fields, fundamental theorem for line integrals ,Green's theorem ,Veteran's day,Curl and divergence, Surface area ,Surface integrals, Stokes theorem ,The divergence theorem

Reference Materials:

1. James Stewart, Multivariable Calculus, Early transcendentals for UC Berkeley, 7th edition (January 1, 2011). (http://calstudentstore.berkeley.edu/courselisting/index/loadMaterials)
2. Vector Calculus, fourth edition, by Susan J. Colley, 4th Edition. (September 28, 2011)

Course Name: **Linear Algebra (AI-356)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **Calculus and Analytic Geometry**
Course Introduction:
To provide fundamentals of solution for system of linear equations, operations on system of equations, matrix properties, solutions and study of their properties.

Course objectives:
The main aim of this course is to give students some basic ideas of calculus, which is the mathematics of motion. The purpose is not just making the students learn these ideas but to enable them apply these ideas to solve problems of practical nature. It will help the students of engineering, computer science and bioinformatics to understand and solve the problems of mathematical and logical nature in other courses of these disciplines.

Course Learning Outcomes:

1. Understand and manipulate vector and matrix operations.
2. Solve systems of linear equations using various methods.
3. Grasp the concepts of vector spaces, subspaces, bases, and dimensions.
4. Apply eigenvalues and eigenvectors in practical scenarios, especially in AI and machine learning models.
5. Use linear transformations to model real-world problems in AI.
6. Implement linear algebra operations using computational tools such as Python and MATLAB.

Course Outline:
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, 10th edition. (January 1, 2010)
2. Linear Algebra and its Applications by Gibert Strang, 4th edition. (January 1, 2006)

Course Name: **Probability and Statistics (AI-459)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **None**
Course Introduction:
To introduce the concepts of data analysis, presentation, counting techniques, probability and decision making.

Course objectives:
To provide students a deeper understanding about the statistical data its types, collection, interpretation and analysis of data. Learn and use the concepts of theory of Probability. To provide students, the knowledge of Discrete and Continuous Probability distribution and their applications in computer engineering. To enable the students to learn and apply the tools for curve fitting via Linear Regression and Correlation.

Course Learning Outcomes:
1. Understand and apply the basic principles of probability theory.
2. Analyze data using statistical methods and draw valid conclusions.
3. Use probability models to describe random processes and uncertainty.
4. Apply statistical techniques in AI and machine learning problems.
5. Use software tools for statistical analysis and data visualization.

Course Outline:
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 S2, t-Distribution, FQuantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of PValues for Decision Making in Testing Hypotheses (Single Sample & One- and TwoSample 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.

Reference Materials:

1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, Pearson, 9th edition. (January 6, 2011)
2. Probability and Statistics for Engineers and Scientists by Anthony J. Hayter, (4th edition. January 1, 2012)
3. Schaum's Outline of Probability and Statistics, by John Schiller, R. Alu Srinivasan and Murray Spiegel, 3rd edition.(August 26, 2008)

Course Name **Technical and Business Writing (AI-558)**
Credit Hours **3 (3+0)**
Contact Hours **3-0**
Pre-requisites Expository Writing
Course Introduction:

Students in the senior level needs good technical writing skills not only for writing project report but also useful for them to communicate their resume and get place in the market. This is a high level course which provide useful knowledge to the students for writing proposals etc. Further, the course aims at augmenting students' 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. 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

Course Learning Outcomes:

1. **Apply Effective Communication Strategies**: Demonstrate the ability to write clearly, concisely, and persuasively for various business and technical audiences.
2. **Craft Professional Documents**: Develop a range of professional documents, including reports, proposals, manuals, and correspondence, using appropriate formats and language for each type.
3. **Analyze Audience and Purpose**: Assess audience needs and tailor documents to meet specific business or technical objectives.

Course Outline:

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

Course objectives:

Every individual, in a professional life, has to interact with people inside as well as outside the concerned organization by means of writing in formal capacity. The students would be taught all the different styles of documentation with greater emphasis on the latest format that is presently in use in most parts of the world. They would be required to prepare all these documents one by one after they have been taught in detail about the various technicalities of composing these formal pieces of writing. They would be expected to have field survey as well, so that they may bring samples of these documents from a variety of private as well as public sector organizations for the sake of know-how about the latest market trends in the said field.

Reference Materials:

1. Technical Report Writing, by Pauley and Riordan, Houghton Mifflin Company, 8th Edition. (January 1, 2002).
2. Effective Technical Communication by Ashraf Rizvi, Tata McGraw-Hill. (2017).

General Education Requirement (GE):

BS – Artificial Intelligence - General Education Requirement (39/137) 15 Courses		
Sr. No.	**Course Title**	**Cr. Hrs.**
1	Applications of Information & Communication Technologies	3
2	Functional English	3
3	Expository Writing	3
4	Quantitative Reasoning – 1 (**Discrete Structures**)	3
5	Quantitative Reasoning – 2 (**Calculus and Analytic Geometry**)	3
6	Islamic Studies	2
7	Ideology and Constitution of Pakistan	2
8	Social Sciences (**URDU**)	2
9	Natural Science (**Applied Physics**)	3
10	Arts & Humanities (**Professional Practices**)	3
11	Civics and Community Engagement	2
12	Entrepreneurship	3
13	Pakistan Studies	2
14	Internship	3

Course Name: **Applications of Information and Communication Technologies (AI-353)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:

This is an introductory course in Computer Science designed for beginners. Apart from leading the participants through a whirlwind history of computing, the course also develops a feel for web programming through a series of lectures that help the students develop their own web page. Main objective of the course is to build an appreciation for the fundamental concepts in computing and to become familiar with popular PC productivity software.

Course objectives

In order to achieve this aim, the course has a set of objectives. Each unit has specific objectives which are included at the beginning of the unit. You are expected to read these objectives before you study the unit. You may wish to refer to them during your study to check on your progress. You should always look at the unit objectives after completion of each unit. By doing so, you would have followed the instructions in the unit. Below are the comprehensive objectives of the course as a whole. By meeting this objective, you should have achieved the aim of the course. Therefore, after going through this course you should be able to explain the principles and practices in Information and Communication Technology. Identify uses, types and advantages of Databases and Computer Networks. Discuss the importance and infrastructural use of Distributed Networks, the Internet and W3. Explain how Information and Communication Technology Applications are managed by personal, enterprise and businesses, and the strategies they used to survive. Know the challenges posed by Information and Communication Technology and the provided solutions.

Course Learning Outcomes:

1. Understand basics of computing technology
2. Do number systems conversions and arithmetic
3. Have knowledge of types of software
4. Have knowledge of computing related technologies

Course Outline:

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 Computers (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, and Decentralized Computing Facility, 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.

Reference Materials:

1. Understanding Computers: Today and Tomorrow, Charles S. Parker, 16th edition. (February 18, 2016)
2. An introduction to automatic digital computers by Livesley, Robert Kenneth, 1st edition. (February 23, 2017)
3. Exploring four decades of research in Computers & Education by Zawacki-Richter, Olaf, and Colin Latchem, (2018).
4. Computer fundamentals by Sinha, Pradeep K., and Priti Sinha, 8th edition. (January 1, 2003)
5. Computer fundamentals by Goel, Anita, 1st edition. (December 1, 2010)

Course Name: **Functional English (AI-359)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **None**
Course Introduction:

This is first course in English to the Bachelor of Science students and covers all the fundamental concept of English composition and comprehension. The course is designed in such a way that students can use this knowledge to further enhance their language skills in English. The course aims at enhancing students' skill and competence in communicating their ideas in writing and speaking in English language. 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, build-up vocabulary, and clearly and accurately reproduce specific data. It will illustrate the force and effectiveness of simple and direct English.

Course objectives

To develop in the learners the ability to listen, read and understand English to train students' ears to understand English uttered by speakers. To help students read extensive readings for information, pleasure and enlightenment. To help students reinforce grammatical points already taught. To teach students to practice important writing techniques. To develop in the learners the ability to promote the writing skill until they are able to write a complete paragraph and are ready to do any writing required in the university or in life. To enable students to survive in the real world using English. To teach new structures and words. To enable students to understand what they hear on a variety of topics. To enable students speak good English. To teach the basic tenses of present, past and future. To develop in the learners the ability to read and enjoy English written with their own vocabulary without depending on the teacher for explanation and translation. To provide the students with a store of structures and words that help them to write simple, guided paragraphs.

Course Learning Outcomes:

1. Enhance their understanding and application of English grammar.
2. Develop a strong vocabulary relevant to academic and professional use.
3. Improve their reading comprehension and critical analysis of texts.
4. Strengthen their writing skills, focusing on academic and technical writing.
5. Gain confidence in oral communication, including presentations and discussions.
6. Learn techniques for effective communication in professional environments.
7. Writing academic and technical reports.

Course Outline:
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 Materials:
1. College Writing Skills with Readings, by John Langan, McGraw-Hill, 11th edition.(January 1, 2022)
2. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute, (2017).

Course Name: Expository Writing **(AI-360)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **Functional English**

Course Introduction:

Expository Writing is built on the premise that the craft of good explanatory and descriptive writing is inseparable from the ability to read widely, critically and efficiently. And so, even as English II consolidates the groundwork done in the English I module it advances in two skill areas, in particular. Firstly, it seeks to enable students to skillfully read pieces in diverse genres—including texts in English relevant to their respective fields of study. Secondly, it looks to empower students to produce a variety of argumentative and explanatory texts. The course also expands on students' grammar and vocabulary skills, as building blocks of written communication, relevant to the academic and prospective professional needs of learners. As in English I, communication proficiency goals are critically integrated with the broader educational, social and professional concerns within the Pakistani postcolonial setting.

Course objectives

The course aims to upgrade the spoken and written English of the Electronic Engineering students from an intermediate to advanced level, and to help them overcome their fear of public speech. It will also focus on introducing the basic research skills and writing skills affiliated to research, to help them in writing research papers for the contemporary Engineering courses. It also aims to inculcate confidence and to groom their personality so that they can aim at executive level jobs. The career focus of this course is to build the combination of language and interpersonal skills needed to work independently, to lead teams effectively, and to become customer focused and result driven in their approach. Special emphasis is also laid on developing individual and group effort through virtual and real life training, presentations, projects and research, especially towards developing their leadership qualities and the ability, to improve team functioning and team output.

Course Outline:

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

Course Learning Outcomes:

1. Understand the fundamental principles of communication.
2. Develop effective verbal and non-verbal communication skills.
3. Enhance public speaking and presentation abilities.
4. Learn techniques for professional communication, including emails and reports.

5. Build confidence in delivering technical presentations.
6. Improve their skills in participating in group discussions, debates, and meetings.

Reference Materials:
1. Practical Business English, Collen Vawdrey, (1993).
2. Effective Communication Skills: The Foundations for Change, John Nielsen, (2008.)
3. College Writing Skills with Readings, by John Langan, 11th edition. (January 1, 2022)
4. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute (July 15, 2011)

Course Name: **Discrete Structures (AI-358)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **None**
Course Introduction:
Introduces the foundations of discrete mathematics as they apply to Computer Science, focusing on providing a solid theoretical foundation for further work. Further, this course aims to develop understanding and appreciation of the finite nature inherent in most Computer Science problems and structures through study of combinatorial reasoning, abstract algebra, iterative procedures, predicate calculus, tree and graph structures. In this course more emphasis shall be given to statistical and probabilistic formulation with respect to computing aspects.

Course objectives:
To lay the foundations for theoretical computer science. To understand the basic mathematical concepts generally required for most computer science courses. Developing precise and formal reasoning skills in students. Exploring different ways of mathematical thinking i.e. Logical thinking, Relational thinking, Recursive thinking, Quantitative thinking and Analytical thinking.

Course Learning Outcomes:
1. Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.
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.
3. Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.
4. Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular

Course Outline:
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, mapping , function composition, inverse functions, recursive functions, Number Theory, sequences, series, counting, inclusion and exclusion principle, pigeonhole principle, permutations and combinations. Algorithms, Searching and Sorting Algorithms, elements of graph theory, planar graphs, graph coloring, Graph Algorithms, Euler graph, Hamiltonian path, rooted trees, traversals.,

Reference Materials:

1. Discrete Mathematics and Its Applications by Kenneth H. Rosen, 8th edition. (July 9, 2018)
2. Discrete Mathematics with Applications by Susanna S. Epp, 4th edition. (August 4, 2010)
3. Discrete Mathematics by Richard Johnson Baugh, 8th edition. (March 6, 2017)
4. Discrete Mathematical Structures by Kolman, Busby & Ross, 4th edition. (November 23, 1999)
5. Discrete and Combinatorial Mathematics: An Applied Introduction by Ralph P. Grimaldi, 5th edition. (July 27, 2003)
6. Logic and Discrete Mathematics: A Computer Science Perspective by Winifred, (2007).

Course Name: **Calculus and Analytical Geometry (AI-355)**
Credit Hours: **3 (3+0)**
Contact Hours: **3**
Pre-requisites: **None**
Course Introduction:
To provide foundation and basic ground for calculus and analytical geometry background.

Course objectives:
To learn fundamentals of mathematics, calculus and analytical geometry. To enable students to apply ideas to solve problems of practical nature.

Course Learning Outcomes:

1. Understand the fundamental concepts of differential and integral calculus.
2. Apply calculus to solve problems in optimization, curve sketching, and area calculation.
3. Analyze and interpret conic sections using analytical geometry.
4. Utilize calculus concepts in AI applications such as machine learning algorithms, neural networks, and robotics.
5. Develop problem-solving skills relevant to AI technologies through mathematical modeling.

Course Outline:
Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of funding 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 R3, Equations for planes.

Reference Materials:

1. Calculus and Analytic Geometry by Kenneth W. Thomas. 9th edition. (August 14, 1995)
2. Calculus by Stewart, James. 9th edition. (April 30, 2020)
3. Calculus by Earl William Swokowski; Michael Olinick; Dennis Pence; Jeffery A. Cole, 6th edition. (September 25, 1996)

Course Name: **Islamic Studies (AI-361)**
Credit Hours: **2 (2+0)**
Contact Hours: **2-0**
Pre-requisites: **None**

Course Introduction:

To provide Basic information about Islamic Studies. To enhance understanding of the students regarding Islamic Civilization. History of Islam, understanding of the worship and its usefulness. The basic concept of Quran Pak: wisdom, patience, loyalty. The comparative analysis of Islam with other religions. The Concept and Value of Haqooq ul Ibad (Bandon Kay Haqooq) in Islam. What is The rights of people in Islamic Point of View? Islamic point of view about other religions.

Course objectives

This course has been designed as a compulsory subject for the students of Bachelor's degree program. This course introduces about principles of recitation of Holy Quran and provides sufficient knowledge on faith & pillars of Islam than systems of Islam. The main objective of this course is to enhance knowledge of the students on Islam and their character building.

Course Learning Outcomes:

1. To further enhance the knowledge of Islam.
2. To understand the basic concept of Islam and Quran Pak.
3. To understand the concept of Haqooq ul ibad in the light of Quran.
4. To know the importance of Islamic concept about other religions.

Course Outline:

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. Definition of Akhlaq.The Most Important Characters mentioned in the Holy Qur'an and Sunnah, SIDQ (Truthfulness)Generosity Tawakkaul (trust on Allah) Patience Taqua (piety). Haqooq ul ibad in the light of Quran & Hadith - the important characteristic of Islamic Society.

Reference Materials: (or use any other standard and latest books)

1. Introduction to Islam by Dr Hamidullah, Papular Library Publishers Lahore(2020)
2. Principles of Islamic Jurisprudence by Ahmad Hassan, Islamic Research Institute, IIUI, (1993).
3. Muslim Jurisprudence and the Quranic Law of Crimes, By Mir Waliullah, Islamic Books Services, (1982).

Course Name: **Ideology and Constitution of Pakistan (AI-362)**
Credit Hours: **2 (2+0)**
Contact Hours: **2-0**
Pre-requisites: **None**
Course Introduction:
Pakistan studies is an important course at this university in which students' study about their motherland. The following are the specific objective of the course: To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan. To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course objectives:
Acquaint the students with the meaning and significance of the Ideology and constitution of Pakistan as a compulsory subject. To develop the qualities of patriotic Pakistanis for understanding and fulfilling their duties and responsibilities. To develop a sense of belongingness to their motherland and a strong faith in the basic concepts of Pakistan's ideology and introduction of Pakistan's historical background. To create awareness about the Constitutional Developments in Pakistan. To promote the knowledge of the importance of Pakistani culture and civilization. To make the new generation aware of current affairs and important pillars of Pakistan's foreign policy.

Course Learning Outcomes:
1. To educate students about the history of Pakistan
2. To educate students about the various pillar of the state
3. To educate student Government and politics

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

Reference Materials: (or use any other standard and latest books)
1. The Emergence of Pakistan, Chaudary M., (2009 Edition)
2. The making of Pakistan, Aziz. (2013 Edition)
3. A Short History of Pakistan, I. H. Qureshi, ed., Karachi, 2nd Edition (2000)

Course Name: Fehm e Quran (AI-444)
Credit Hours: 2 (2+0)
Contact Hours: 2-0
Pre-requisites: None

Course Introduction:

A "Fehm-e-Quran" course aims to provide a deep understanding of the Holy Quran by going beyond translation to teach its meaning, themes, and context through the study of Arabic

grammar and Tafsir.

Course objectives

To provide students with a practical and direct understanding of the Quran, focusing on linguistic comprehension of verses and building the ability to comprehend the text independently. The course aims for students to understand a significant portion of the Quranic text and its basic and advanced linguistic components.

Course Learning Outcomes:

1. Interpret Quranic verses using various methodologies of Tafsir
2. Discuss the implications of Quranic teachings in contemporary life
3. Adopt and practice the teachings of the Quran in their daily life.

Course Outline:

This course mainly focuses on basic words, phrases, and sentences without verbs, and progresses to sentences with present tense verbs, past tense verbs and translating verses from the Quran.

Reference Materials: (or use any other standard and latest books)

Muallim ul Quran (Volume 1, 2 & 3) by Dr Ubaid ur Rahman

Course Name: **Pakistan Studies (AI-364)**
Credit Hours: **2 (2+0)**
Contact Hours: **2-0**
Pre-requisites: **None**

- As per University of Karachi Policy.

Course Name: **Applied Physics (AI-357)**
Credit Hours: **3 (2+1)**
Contact Hours: **2-3**
Pre-requisites: **None**

Course Introduction:

The course introduces basic concept of Physics and Electronics. Students are also taught Physics laws and other associate topics to prepare them for the advanced level courses in this area. The focus of the course is on electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force and many other useful topics.

Course objectives:

The primary objective is to endow the knowledge of a wide variety of electric and magnetic phenomena along with their scientific applications, specifically, in the field of electronic engineering. The course initiates with a short review of relevant mathematics, immediately followed by the basics of electricity at the atomic level. A majority of the course is then dedicated for electric and magnetic fields, forces, elements and their applications. Additionally, it also aims to provide introductory knowledge of wave theory and semi-conductor theory in conjunction with their applications.

Course Learning Outcomes:

Applied Physics course, you will be able to apply core physics principles to real-world problems and conduct experiments that demonstrate these concepts. You will also enhance your analytical skills and effectively communicate scientific ideas.

Course Outline:

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.

Reference Materials: (or use any other standard and latest books)

1. Fundamentals of Physics (Extended) by Resnick and Walker, 10th edition. (August 13, 2013)
2. Physics for Computer Science Students by Narciso Garcia, Arthur Damask, Steven Schwarz, 2nd edition.(January 9, 1998)

Course Name: **Urdu (AI-461)**
Credit Hours: **2 (2+0)**
Contact Hours: **2-0**
Pre-requisites: **None**

- As per University of Karachi Policy.

Course Name: **Professional Practices (AI-554)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:
A Computing graduate as professional has some responsibilities with respect to the society. This course develops student understanding about historical, social, economic, ethical, and professional issues related to the discipline of Computing. It identifies key sources for information and opinion about professionalism and ethics. Students analyze, evaluate, and assess ethical and professional computing case studies.

Course objectives:
The Professional Practices course aims to equip students with essential skills and ethical standards for thriving in today's workplace. Students will explore professional conduct, effective communication, teamwork, project management, and the ethical responsibilities of their field. Through case studies, discussions, and practical exercises, they will gain insights into workplace expectations, learn to navigate challenges, and develop strategies for continuous improvement and career growth. This course will prepare students to demonstrate integrity, accountability, and professionalism, key qualities for advancing in their chosen professions.

Course Learning Outcomes:
Professional Practices" course, you will develop key skills in ethical decision-making and effective communication in a professional environment. You will also learn how to navigate workplace dynamics and enhance your collaboration and leadership abilities.

Course Outline:
Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology); Definitions of Computing (software engineering, Computer Science, Information Technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities, software related contracts, Software house organization. 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.

Reference Materials: (or use any other standard and latest books)
1. Professional Issues in Software Engineering by Frank Bott, Allison Coleman, Jack Eaton

and Diane Rowland, 3rd edition. (21 September 2000)
2. Computer Ethics by Deborah G. Johnson, Pearson, 4th edition. (December 24, 2008)
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet by Sara Baase, 3rd edition. (January 6, 2008)
4. Applied Professional Ethics by Gregory R. Beabout (December 9, 1993)

Course Name: **Internship (AI-653)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

- **As per University of Karachi Policy.**

Course Name: Professional Certification (AI-610)

Credit Hours: 3 (0+3)

Contact Hours: 3-0

Pre-requisites: None

Course Introduction:

Integration of International Professional Certifications into BS Computer Science Program.

1. To recognize selected international certifications as equivalent to **one elective (3 credit hours)** in BS Computing programs.

2. To ensure that recognition of certifications does not compromise academic integrity or NCEAC accreditation standards.

3. To enhance employability of graduates by combining formal degree education with verifiable industry credentials.

4. List of certifications recommended by PSEB – Ministry of IT & Telecom will be approved by BoS, BoF, and Academic Council and the university may add more certifications.

5. Government and other funding avenues will cover the cost of certifications for the university students and affiliated colleges.

Course Learning Outcomes:

As per guidelines of NCEAC and HEC

Course Outline:

As per guidelines of NCEAC and HEC

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Course Name: **Entrepreneurship (AI-660)**
Credit Hours: **3 (3+0)**
Contact Hours: **3-0**
Pre-requisites: **None**

Course Introduction:

This course aims to provide students with a basic understanding of the principles and practices of entrepreneurship. It also aims to cultivate an entrepreneurial mindset and equip students with the knowledge and skills necessary to start, manage, and grow their own ventures. Learning components of 'Financial Literacy' and 'Export Management' are also included in the learning outcomes of the course to provide students with a holistic understanding of business in priority areas of the economy

Course objectives:

Entrepreneurship is an interdisciplinary course designed to teach students how to think and act entrepreneurially. Students learn how to start-ups and operate a business. The course will build cross-curricular academic skills, by integrating inquiry-based learning and business tools that will enable students to analyze, create, develop and pilot small businesses. Concepts and skills are reinforced by a strong emphasis on hands-on experiences. Applications to society, individuals, and the utilization of technology are included. This course includes a broad series of lessons and activities that offer a variety of modalities for ultimate student engagement and content retention.

Course Outline:

1. Introduction to Entrepreneurship, Perspectives, Benefits and Drawbacks. Types of Entrepreneurs. Cultural Diversity and Entrepreneurship. Contexts of entrepreneurial activity.
2. Characteristics of Entrepreneur: Creativity, Professionalism, Risk-taking, Planning etc.
3. Entrepreneurial functions, Managerial Functions: Planning, Organizing, Staffing, Directing, Controlling.
4. Generating Ideas, Creativity and Innovation, Conceptual framework and Techniques.
5. Feasibility Analysis: Product, Service, Marketing, Financial.
6. Development of Business Plan, Business models, Guidelines, General Categories.
7. Business Marketing, Strategies for Marketing. Creating Values for Customers.
8. Strategic Management Process, Steps of Strategic Management Process.
9. Leadership and Social Entrepreneurship.
10. Intrapreneurs, History of Intrapreneurship, Benefits of Intrapreneurship, Characteristics of an Intrapreneur. Comparison of Managers, Intrapreneurs and Entrepreneurs.
11. Ethical and Legal issues for Permits and Licensing. Intellectual Property Rights.
12. Finance and Funding, Sources of Personal financing, Debit and Equity Financing. Franchising.
13. The Process of Growth, Reasons, Strategies, Readiness, and Challenges of Entrepreneurship.

Reference Materials:

1. Entrepreneur: What It Means to Be One and How to Get Started". December 2022.
2. Martiarena, A. (2013). What's so entrepreneurial about intrapreneurs? Small Business Economics, 40(1), 27-39. doi:10.1007/s11187-011-9348-1 Mason, C., & Brown, R. (2014). Entrepreneurial ecosystems and growth oriented entrepreneurship. Retrieved from The Hague, Netherlands: http://www.oecd.org/cfe/leed/entrepreneurial-ecosystems.pdf Matthews, C. H., & Brueggemann, R. (2015). Innovation and entrepreneurship: A

competency framework. New York: Routledge.

3. Matzler, K., Veider, V., & Kathan, W. (2015). Adapting to the sharing economy. MIT Sloan Management Review, 56(2), 71-77.
4. Carree, M. A., Thurik, A. R. "The impact of entrepreneurship on economic growth" In: Audretsch, D. B., Acs, Z. J. (eds). Handbook of Entrepreneurship Research. Berlin: Springer Verlag, 2010.

Course Name: **Civics and Community Engagement (AI-559)**
Credit Hours: **2 (2+0)**
Contact Hours: **2-0**
Pre-requisites: **None**
Course Introduction:
This course aims to bring responsible citizenship and active engagement between Universities/HEIs (through their students) and local communities. The course will provide students with a foundational understanding of the principles, institutions, and processes of civic engagement in a democratic society. Moreover, the course will build the capacity of students as leaders and influencers by gaining fundamental understanding of leadership, citizenship, communication, advocacy, network building as well as having first-hand experience of community development through volunteer work**.**

Course objectives
The Civics and Community Engagement course is designed to help students understand the principles of civic responsibility, government functions, and the importance of active citizenship in fostering positive change. Through discussions, projects, and community engagement activities, students will explore the structures of government, social justice issues, and methods for impactful community involvement. The course aims to inspire students to be informed citizens, to advocate for social issues, and to contribute meaningfully to their communities, emphasizing the power of civic participation in strengthening society.

Course Learning Outcomes:

1. **Understand Civic Responsibilities**: Explain the principles of civic duty, community involvement, and the roles of government and individuals in society.
2. **Analyze Social Issues**: Identify and analyze pressing social, political, and economic issues within local, national, and global contexts, understanding their impact on communities.
3. **Engage in Community-Based Learning**: Participate in activities that foster community engagement, applying course concepts to real-world scenarios through volunteer work, community projects, or partnerships.
4. **Develop Critical Thinking on Public Policy**: Evaluate public policies and proposals, considering their implications for social justice, equity, and community well-being.
5. **Practice Effective Communication and Advocacy**: Demonstrate skills in communicating ideas, advocating for community needs, and engaging with diverse audiences through written, oral, and digital means.
6. **Reflect on Personal and Social Impact**: Assess personal values and actions in relation to civic responsibilities, exploring how individual contributions can promote positive social change.
7. **Collaborate for Community Solutions**: Work collaboratively on community-based projects, developing strategies to address social issues and strengthen community resilience.

Course Outline:

1. Introduction to Civics and Community Engagement
2. Fundamentals of Civic Responsibility
3. Government and Policy-Making
4. Community Issues and Social Justice
5. Advocacy and Activism
6. Community Service and Volunteering
7. Engagement through Digital Platforms
8. Building and Leading Community Initiatives
9. Case Studies in Civic Engagement
10. Personal Civic Action Plan

Reference Materials:

- As per University of Karachi policy.

Appendix – A

Mapping of BSAI Program on the Generic Structure:

#	Sem #	Course Code	Pre-Reqs	Course Title	Course Category	Cr. Hrs.
Computing Core (46/130) 14 Courses						
1	1	CS1xx		Programming Fundamentals	Core	4 (3+3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3+3)
3	2	CS1xx		Database Systems	Core	4 (3+3)
4	2	CS1xx		Digital Logic Design	Core	3 (2+3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3+3)
6	3	CS2xx		Information Security	Core	3 (2+3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2+3)
8	3	CS2xx		Data Communication Networking	Core	3 (2+3)
9	3	CS2xx		Software Engineering	Core	3 (3+0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2+3)
11	5	CS3xx		Operating Systems	Core	3 (2+3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3+0)
13	7	CS4xx		Final Year Project - I	Core	2 (0+6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0+12)
Domain Core (18/130) 6 Courses						
15	4	CS2xx		Programming for AI	Domain Core	3 (2+3)
16	4	CS2xx		Machine Learning	Domain Core	3 (2+3)
17	5	CS3xx		Artificial Neural Networks & Deep Learning	Domain Core	3 (2+3)
18	5	CS3xx		Knowledge Representation & Reasoning	Domain Core	3 (2+3)
19	6	CS3xx		Computer Vision	Domain Core	3 (2+3)
20	6	CS3xx	OS	Parallel & Distributed Computing	Domain Core	3 (2+3)
Domain Elective (21/130) 7 Courses						
21	5	CS3xx		Natural Language Processing	Domain Elective	3 (2+3)
22	5	CS3xx		Speech Processing	Domain Elective	3 (2+3)
23	6	CS3xx		Data Mining	Domain Elective	3 (2+3)
24	6	CS3xx		Advanced Statistics	Domain Elective	3 (2+3)
25	6	CS3xx		Reinforcement Learning	Domain Elective	3 (2+3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2+3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2+3)
.				Fuzzy Systems	Domain Elective	3 (2+3)
.				Swarm Intelligence	Domain Elective	3 (2+3)
.				Agent Based Modeling	Domain Elective	3 (2+3)

.				Knowledge Based Systems	Domain Elective	3 (2+3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3+0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3+0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3+0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3+0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3+0)
		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3+0)
General Education Requirement as per HEC UG/KU Education Policy (34/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2+3)
34	1	GE1xx		Functional English	GER	3 (3+0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3+0)
36	1	GE1xx		Quantitative Reasoning – 1 (**Discrete Structures**)	GER	3 (3+0)
37	1	GE1xx		Quantitative Reasoning – 2 (**Calculus and Analytic Geometry**)	GER	3 (3+0)
38	4	GE2xx		Islamic Studies	GER	2 (2+0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2+0)
40	4	GE2xx		Social Sciences (Example: **Introduction to Management**)	GER	2 (2+0)
41	4	GE2xx		Natural Sciences (**Applied Physics**)	GER	3 (2+3)
42	8	GE4xx		Arts & Humanities (**Professional Practices**)	GER	2 (2+0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2+0)
44	7	GE4xx		Entrepreneurship	GER	2 (2+0)