Annexure-B

Curriculum for
BS Artificial Intelligence

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF PESHAWAR
SESSION 2024

1 BS Artificial Intelligence

This bachelor's degree program in Artificial Intelligence (BS AI) at Department of Computer Science, University of Peshawar will equip our students with a comprehensive grasp of AI principles and their practical applications. This program encompasses foundational knowledge in computer science, artificial intelligence, mathematics, and statistics. Students explore various facets of machine learning, encompassing supervised and unsupervised learning, alongside deep learning methodologies employing neural networks. They acquire proficiency in data science, encompassing data analysis and manipulation. Additionally, coursework may include subjects such as natural language processing, deep learning, and ethical considerations in AI. Through hands-on projects, students apply their learning, with opportunities to specialize in fields like computer vision or AI applications in business. The curriculum adapts to the rapid advancements in AI technology and its diverse applications.

Imparting the necessary skill set required by the industry to future artificial intelligence graduates is quite a challenge in an academic setting. To address this, an Artificial Intelligence curriculum must focus on the concepts most needed by new graduates entering the workforce. This skillset, identified by ACM in Computer Science Curricula 2023 report[1], includes compulsory hands-on projects in identifying a problem, gathering data, data cleaning & preprocessing, exploratory data analysis, model selection, model training, evaluation, deployments and maintenance with documentation and reporting by utilizing state of the art AI tools. This program offered by the department is designed keeping in view this skillset by following the guidelines of HEC-NCEAC[2] and HEC Undergraduate Policy[3] where applicable.

1.1 The Program Educational Objectives for BS AI Program

The Program Educational Objectives (PEOs) of our BS Artificial Intelligence program are designed to prepare graduates comprehensively for diverse careers spanning industry, academia, government, and beyond. Our goal is to enable graduates to contribute effectively to the responsible development and deployment of AI technologies. Our Program Educational Objectives are outlined as follows:

PEO (1): Deep Knowledge & Skills: Acquire deep knowledge and practical skills in computing with a specialization in Artificial Intelligence, enabling them to design, develop, and implement intelligent systems and applications that address real-world challenges.

PEO (2): Problem Solving & Communication: Analyze, evaluate, and resolve complex AI problems according to stakeholder requirements. Graduates will effectively communicate the design and functionality of AI systems, elucidating their implications.

PEO (3): Ethics & Conduct: Demonstrate ethical and professional conduct, understanding the social, legal, and ethical implications of AI systems and their societal impact.

PEO (4): Lifelong Learning: Develop skills for lifelong learning and professional growth, staying current with the latest advancements and trends in AI and computing fields.

[1] https://csed.acm.org/wp-content/uploads/2023/03/Version-Beta-v2.pdf

[2] https://nceac.org.pk/Documents/Curriculums/BS%20Curriculm%20Computing%20Disciplines-2023.pdf

[3] https://www.hec.gov.pk/english/services/students/UEP/Documents/UGE-Policy.pdf

1.2 Program Learning Objectives (PLOs) for BS AI Program

The goals and achievements of graduates of our BS Artificial Intelligence program are guided by the following Program Learning Outcomes (PLOs):

S#	Program Learning Outcomes	Computing Professional Graduate
1	Academic Education	Prepare graduates to become skilled computing professionals.
2	Knowledge for Solving Computing Problems	Apply computing fundamentals, specialized knowledge, and relevant mathematics and science to abstract and conceptualize computing models from defined problems and requirements.
3	Problem Analysis	Identify, formulate, research literature, and solve complex computing problems, reaching well-founded conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.
4	Design/Development of Solutions	Design and evaluate solutions for complex computing problems, and develop systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
5	Modern Tool Usage	Create, select, adapt, and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of their limitations.
6	Individual and Teamwork	Function effectively both as an individual and as a member or leader in diverse teams and multidisciplinary settings.
7	Communication	Communicate effectively with the computing community and society at large about complex computing activities by comprehending and writing effective reports, designing documentation, making effective presentations, and giving and understanding clear instructions.
8	Computing Professionalism and Society	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the associated responsibilities relevant to professional computing practice.
9	Ethics	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.
10	Life-long Learning	Recognize the need for, and have the ability to engage in, independent learning for continual development as a computing professional.

1.3 Mapping Matrix for the Program's PEOs to PLOs

The following is the mapping matrix for the Program Educational Objectives (PEOs) to Program Learning Outcomes (PLOs) for BS AI program:

S#	Program Learning Outcomes (POLs)	Program Educational Outcomes (PEOs)			
		PEO-1	PEO-2	PEO-3	PEO-4
1	Academic Education	✔			
2	Knowledge for Solving Computing Problems	✔	✔		
3	Problem Analysis	✔	✔		
4	Design/Development of Solutions	✔	✔		
5	Modern Tool Usage	✔	✔		
6	Individual and Teamwork		✔		
7	Communication		✔		
8	Computing Professionalism and Society			✔	
9	Ethics			✔	
10	Life-long Learning				✔

2 HEC-NCEAC Curriculum Model for BS Artificial Intelligence

The HEC-NCEAC Curriculum Model has been adopted for the BS in Artificial Intelligence and presented as follows:

2.1 Overall General Split of Curriculum for BS Artificial Intelligence

The required number of courses and credit hours to be taken from 6 broad areas of BS AI are as follows:

S. No.	Areas	Credit Hours	Courses
1	Computing Core	46	14
2	Domain Core	18	06
3	Domain Electives	21	07
4	Mathematics & Supporting	12	04
5	Elective Supporting	03	01
6	General Education	30	12
	Total	**133**	**44**

2.2 Area Wise Curriculum Split for BS Artificial Intelligence

The course name, course code, prerequisites, and credit hour breakdown for each course in each area are provided in the following table:

#	Sem #	Code	Pre-Req	Course Title	Domain	Cr Hrs
Computing Core (46/130) 14 Courses						
1	1	CS102	-	Programming Fundamentals	Computing Core	4(3-3)
2	2	CS123	CS102	Object Oriented Programming	Computing Core	4(3-3)
3	2	CS122	-	Digital Logic Design	Computing Core	3(2-3)
4	3	CS202	CS123	Data Structures	Computing Core	4(3-3)
5	3	CS121	-	Database Systems	Computing Core	4(3-3)
6	4	CS203	-	Information Security	Computing Core	3(2-3)
7	3	CS201	CS123	Artificial Intelligence	Computing Core	3(2-3)
8	2	CS206	-	Computer Networks	Computing Core	3(2-3)
9	3	CS204	-	Software Engineering	Computing Core	3(3-0)

10	4	CS207	CS122	Computer Organization and Assembly Language	Computing Core	3(2-3)
11	4	CS208	CS202	Operating Systems	Computing Core	3(2-3)
12	4	CS205	CS202	Analysis of Algorithms	Computing Core	3(3-0)
13	7	CS401	-	Final Year Project – I	Computing Core	2(0-6)
14	8	CS402	CS401	Final Year Project – II	Computing Core	4(0-12)
AI Domain Core (18/130) 6 Courses						
#	**Sem #**	**Code**	**Pre-Req**	**Course Title**	**Domain**	**Cr Hrs**
15	5	CS308	CS201	Programming for Artificial Intelligence	Domain Core	3(2-3)
16	5	CS307	CS201	Machine Learning	Domain Core	3(2-3)
17	6	CS315	CS307	Artificial Neural Network and Deep Learning	Domain Core	3(2-3)
18	6	CS331	CS201	Knowledge Representation and Reasoning	Domain Core	3(2-3)
19	7	CS328	, CS102	Computer Vision	Domain Core	3(2-3)
20	8	CS403	CS208, CS123	Parallel and Distributed Computing	Domain Core	3(2-3)
AI Domain Elective (21/130) 7 Courses						
#	**Sem #**	**Code**	**Pre-Req**	**Course Title**	**Domain**	**Cr Hrs**
21	5-8	CS420	CS201	Natural Language Processing	Domain Elective	3(2-3)
22	5-8	CS345		Speech Processing	Domain Elective	3(2-3)
23	5-8	CS318	CS201,	Data Mining	Domain Elective	3(2-3)
24	5-8	CS302		Advanced Statistics	Domain Elective	3(2-3)
25	5-8	CS343	CS307	Reinforcement Learning	Domain Elective	3(2-3)
26	5-8	CS311	CS102, CS202	Theory of Automata	Domain Elective	3(2-3)
27	5-8	CS319	CS102	Human Computer Interaction (HCI)	Domain Elective	3(2-3)
	5-8	CS337	CS201	Fuzzy Systems	Domain Elective	3(2-3)
	5-8	CS346	CS201	Evolutionary Algorithms	Domain Elective	3(2-3)
	5-8	CS404	CS201	Agent Based Modeling	Domain Elective	3(2-3)

	5-8	CS408	CS201	Knowledge Based Systems	Domain Elective	3(2-3)
	5-8	CS407	CS201	Introduction to Robotics	Domain Elective	3(2-3)
	5-8	CS338	CS307	Generative Artificial Intelligence	Domain Elective	3(2-3)
	5-8	CS347	CS318	Text Mining	Domain Elective	3(2-3)
	5-8	CS327	CS207	Computer Architecture	Domain Elective	3(2-3)
	5-8	CS314	CS123	Advanced Programming	Domain Elective	3(2-3)
	5-8	CS341	CS314	Mobile Application Development	Domain Elective	3(2-3)
Mathematics and Supporting (12/130) 4 Courses						
28	1			Probability & Statistics	Math	3(3-0)
29	4			Multivariate Calculus	Math	3(3-0)
30	5			Applied Linear Algebra	Math	3(3-0)
31	7			Technical and Business Writing	English Writing	3(3-0)
Elective Supporting (3/130) 1 Course						
32	5	MATH-432	-	Computation in MATLAB	Elective Supporting	3(2-3)
Any other University of Peshawar approved computer science related course.						
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	CS101	-	Applications of Information and Communication Technologies (ICT)	General Education	3(2-3)
34	1		-	Functional English	General Education	3(3-0)
35	2		-	Expository Writing	General Education	3(3-0)
36	2	CS120	-	Quantitative Reasoning – 1 (Discrete Structures)	General Education	3(3-0)
37	3		-	Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	General Education	3(3-0)
38	1		-	Islamic Studies	General Education	2(2-0)
			-	Religious Education/Ethics	General Education	2(2-0)
39	1		-	Ideology and Constitution of Pakistan	General Education	2(2-0)
40	7		-	Social Sciences	General Education	3(3-0)

41	4		-	Natural Sciences	General Education	3(2-3)
42	8		-	Arts & Humanities	General Education	3(3-0)
43	8		-	Civics and Community Engagement	General Education	2(2-0)
44	7		-	Entrepreneurship	General Education	3(3-0)

Social Science Courses Pool				
#	**Course Code**	**Course Title**	**Credit Hours**	**Department**
1	SW-682	Project Planning and Management	3(3-0)	Department of Social Work
2	BA 324	Principles of Marketing	3(3-0)	Institute of Management Sciences
3	BA 322	Management	3(3-0)	Institute of Management Sciences
4	Psy-101	Introduction to Psychology – I	3(3-0)	Department of Psychology
Any other University of Peshawar approved course from social sciences.				
Arts & Humanities Courses Pool				
#	**Course Code**	**Course Title**	**Credit Hours**	**Department**
1	CS423	Professional Practices	3(3-0)	Department of Computer Science
2	HIST-106	Introduction to History	3(3-0)	Department of History
3	Phil:311	An introduction to Philosophy	3(3-0)	Department of Philosophy
Any other University of Peshawar approved course from social sciences.				
Natural Sciences Courses Pool				
#	**Course Code**	**Course Title**	**Credit Hours**	**Department**
1		Applied Physics	3(2-3)	
Any other University of Peshawar approved course from social sciences.				

2.3 Semester Plan for BS Artificial Intelligence

The semester-wise study plan for the BS Artificial Intelligence, including each course's title, pre-requisite, area, and credit hours, is provided in the following table:

#	Code	Course Title	Domain	Cr Hr
Semester 1				
1	CS102	Programming Fundamentals	Computing Core	4(3-3)
2	CS101	Applications of Information & Communication Technologies	General Education	3(2-3)

3		Functional English	General Education	3(3-0)
4		Ideology and Constitution of Pakistan	General Education	2(2-0)
5		Islamic Studies	General Education	2(2-0)
		Religious Study/Ethics		
6		Probability & Statistics	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**17(15-6)**
Semester 2				
7	CS122	Digital Logic Design	Computing Core	3(2-3)
8	CS123	Object Oriented Programming	Computing Core	4(3-3)
9	CS206	Computer Networks	Computing Core	3(2-3)
10	CS120	Discrete Structures	General Education	3(3-0)
11		Expository Writing	General Education	3(3-0)
			Total Cr. Hrs	**16(13-9)**
Semester 3				
12	CS121	Database Systems	Computing Core	4(3-3)
13	CS201	Artificial Intelligence	Computing Core	3(2-3)
14	CS202	Data Structures	Computing Core	4(3-3)
15	CS204	Software Engineering	Computing Core	3(3-0)
16		Calculus and Analytical Geometry	General Education	3(3-0)
			Total Cr. Hrs	**17(14-09)**
Semester 4				
17	CS203	Information Security	Computing Core	3(2-3)
18	CS205	Analysis of Algorithms	Computing Core	3(3-0)
19	CS207	Computer Organization and Assembly Language	Computing Core	3(2-3)
20	CS208	Operating Systems	Computing Core	3(2-3)
21		Natural Sciences	General Education	3(2-3)
22		Multivariate Calculus	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**18(14-12)**
Semester 5				
23	CS3XX	Domain Core 1	Domain Core	3(2-3)
24	CS3XX	Domain Core 2	Domain Core	3(2-3)
25	CS3XX	Domain Elective 1	Domain Elective	3(2-3)
26	CS3XX	Domain Elective 2	Domain Elective	3(2-3)
27		Elective Supporting	Elective Supporting	3(2-3)
28		Applied Linear Algebra	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**18(13-15)**
Semester 6				
29	CS3XX	Domain Core 3	Domain Core	3(2-3)
30	CS3XX	Domain Core 4	Domain Core	3(2-3)
31	CS3XX	Domain Elective 3	Domain Elective	3(2-3)
32	CS3XX	Domain Elective 4	Domain Elective	3(2-3)

33	CS3XX	Domain Elective 5	Domain Elective	3(2-3)
			Total Cr. Hrs	**15(10-15)**
Semester 7				
34	CS401	Final Year Project – I	Computing Core	2(0-6)
35	CS3XX	Domain Core 5	Domain Core	3(2-3)
36	CS4XX	Domain Elective 6	Domain Elective	3(2-3)
37		Technical and Business Writing	English Writing	3(3-0)
38		Entrepreneurship	General Education	3(3-0) *
39		Social Sciences	General Education	3(3-0)
			Total Cr. Hrs	**17(13 -12)**
Semester 8				
40	CS402	Final Year Project – II	Computing Core	4(0-12)
41	CS4XX	Domain Core 6	Domain Core	3(2-3)
42	CS4XX	Domain Elective 7	Domain Elective	3(2-3)
43		Arts & Humanities	General Education	3(3-0)
44		Civics and Community Engagement	General Education	2(2-0)
			Total Cr. Hrs	**15(09-18)**

* The approved course is currently of 3 credit hours. If UG policy is adopted by UOP, this may change to 2 credit hours.

3 Area Wise Course Outline for BS Artificial Intelligence

This section provides detailed Course Outline for all courses from all areas of BS(AI), including the course title, course code, credit hours split, pre-requisite, course introduction, course learning outcomes, and reference materials.

3.1 AI Computing Core Courses

This area of the AI Computing Core consists of 14 courses, totaling 46 credit hours, as outlined below:

Course Name:	**Programming Fundamentals**
Course Code:	CS102
Course Area:	Computing Core
Credit Hours:	4 (3-3)
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 and try to achieve CLOs to the maximum possible level. The course may be taught as language independent. Further, it is up to the university to choose any language for the practical/Lab purpose but that must be latest and market oriented. At the end of the course the students will be able to:

CLO No. Course Learning Outcomes **Bloom's Taxonomy**

		Domain	Level
CLO-1	Understand basic problem-solving steps and logic constructs	C	2 (Understand)
CLO-2	Apply basic programing concepts	C	3 (Apply)
CLO-3	Design and implement algorithms to solve real world problems	C	3 (Apply)

Course Outline

Introduction to Programming and Importance for a CS Graduate, Basics of Programming and Software Development, C++ Development Environment and Basic Program Construction, Header Files and Library Files, Variables and Data Types, Operators (Arithmetic, Logical, Increment, Decrement) and Precedence, Type Conversion, Input and Output Statements in C++, IF Statement, IF -ELSE Statement, ELSE-IF Statement, Conditional Operator Switch Statement, GOTO Statement, Arrays, One Dimensional and Two Dimensional Arrays, FOR Loop, Nested FOR loops, Loops with Arrays, WHILE Loop, DO-WHILE Loop, Break Statement, Continue Statement, Functions and its Importance, Parts of Functions, Passing Arguments to Functions, Returning Values from Functions, Inline Functions, Default Arguments, Recursion, Strings, String Manipulation Functions, Structures and its Importance, Declaring Structures and Structures Variables, Accessing Structures Members, Nested Structures, Passing Structures Function, Enumerations, Array of Structures, Pointers and its Importance, Pointers and Arrays, Pointers and Function (Call by Value and Call by Reference), Pointers and Strings, File Handling in C++, Reading from a File, Writing to a File.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Deitel, Paul, and Harvey Deitel. C++ How to Program. 10th Edition., Prentice Hall, 2016.
2. Lafore, Robert. Object-Oriented Programming in C++. 4th Edition., Sams, 2002.
3. Sahay, S. Object Oriented Programming with C++. 1st Edition., Oxford University Press, 2012.
4. Kanetkar, Yashavant. Basic Programming in C++. 1st Edition., BPB Publications, 2004.

Course Name:	**Object Oriented Programming**
Course Code:	CS123
Course Area:	Computing Core
Credit Hours:	4 (3-3)
Contact Hours:	3-3
Pre-requisites:	Programming Fundamentals

Course Introduction

This course discusses the object-oriented model in programming. Students taking this course would have already taken a course on programming. This will help build good quality software using object-oriented techniques.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Understand principles of object-oriented paradigm	C	2 (Understand)
CLO-2	Identify the objects & their relationships to build object-oriented solution	C	2 (Understand)
CLO-3	Model a solution for a given problem using object-oriented principles	C	3 (Apply)
CLO-4	Examine an object-oriented solution	C	4 (Evaluate)

Course Outline

Object Oriented Programming (OOP) and its Significance as a Modeling Technique. Comparison of Structured Programming and OOP, Classes and Objects in C++, Abstraction, New User Defined Data Types, Creating Objects from Classes, Accessing Member, Access Specifiers, Member Functions, Defining Member Functions, Constructors and Properties, Default Constructor, Constructor Overloading, Copy Constructor, Deep Copy, Shallow Copy, Destructors, "this" Pointer, Constant Member Function, Static Variables, Accessing Static Data Member, Static Member Function, Comparison of Global Variables and Static Variable, Arrays of Objects, Pointer to Objects Templates, Function Templates, Class Templates, Data Encapsulation and Abstraction, Importance of Data Encapsulation and Abstraction, Correctly Using the Access Modifiers, Friend Functions, Composition, Aggregation, Operator Overloading, Overloading Assignment Operator, Friend Function and Operator Overloading, Unary Operators Overloading, Inheritance and Importance, Inheritance in C++, Comparison of Overloading and Overriding, Hierarchy of Inheritance, Types of Inheritance, Private Inheritance, Protected Inheritance Multiple Inheritance Problem in Multiple Inheritance, Polymorphism and Importance, Virtual Functions, Static Binding, Dynamic Binding, Abstract Classes and Concrete Classes, Virtual Destructors, Virtual Functions and Pure Virtual Functions, Virtual Functions Usage, Dynamic Dispatch, Namespaces and Using Namespaces, Memory Management and Importance, Memory Areas(Heap, Stack), Use of new Operator, malloc() and calloc() Functions Calls.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Deitel, Paul, and Harvey Deitel. C++ How to Program. 10th Edition., Prentice Hall, 2016.
2. Lafore, Robert. Object-Oriented Programming in C++. 4th Edition., Sams, 2002.
3. Sahay, S. Object Oriented Programming with C++. 1st Edition., Oxford University Press, 2012.
4. Kanetkar, Yashavant. Basic Programming in C++. 1st Edition., BPB Publications, 2004.

Course Name:	**Digital Logic Design**
Course Code:	CS122
Course Area:	Computing Core
Credit Hours:	2 (2-3)
Contact Hours:	2-3

Pre-requisites: None

Course Introduction

This course introduces digital Logic to the students. The main objective of this course is to establish proficiency in fundamental concepts of Digital logic, and to teach the students Boolean Logic, Boolean algebra, gates, functions, multiple logic circuit designs. A key part of this course is to make the students understand the background processing in the computer.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits	C	2 (Understand)
CLO-2	Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques	C	4 (Analyze) & 6 (Create)
CLO-3	Apply the acquired knowledge to simulate and implement small-scale digital circuits	C	3 (Apply)
CLO-4	Understand the relationship between abstract logic characterizations and practical electrical implementations.	C	2 (Understand)

Course Outline

Introduction to Numbering Systems, Conversion and Complements, Binary Arithmetic, Boolean Algebra, Boolean Functions, Standard and Canonical Forms of Boolean, Functions, Logic Gates, Implementation of Boolean Functions with AND, OR, and Not Gates. Simplification of Boolean Functions by Algebraic Manipulation, Map and Tabulation Methods, Boolean Function Implementation with NAND and NOR Gates. Combinational Logic Design and Analysis, Adders, Subtractions, Code Converters. Combinational Logic with MSI and LSI, Binary Parallel Adder, Decimal Adder, BCD Adder, Magnitude Comparator, Decoders, De-multiplexers, Encoders, Multiplexers, ROMs, PLAs and its Implementations. Sequential Logic, Introduction to Latches, Flip Flops, Types of Flip-Flops, Registers, Counters, Timing Sequence and Memory Unit. Asynchronous Sequential Logic, Digital Integrated Circuits, RTL and DTL Circuits, MOS, CMOS. Digital Logic Simulator as Logic Gate Simulator, Multimedia Logic.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Morris, M. M. Digital Logic and Computer Design. 5th Edition., Pearson Education India, 2009.
2. Floyd, Thomas L. Digital Computer Electronics. 9th Edition., Pearson Education India, 2011.
3. Floyd, Thomas L. Digital Fundamentals. 11th Edition., Pearson, 2011.

Course Name:	Data Structures
Course Code:	CS202
Course Area:	Computing Core
Course Code:	CS202
Credit Hours:	4 (3-3)
Contact Hours:	3-3
Pre-requisites:	Object Oriented Programming

Course Introduction

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

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Implement various data structures and their algorithms and apply them in implementing simple applications	C	3 (Apply)
CLO 2	Analyze simple algorithms and determine their complexities.	C	4 (Analyze)
CLO 3	Apply the knowledge of data structure to other application domains.	C	3 (Apply)
CLO 4	Design new data structures and algorithms to solve problems.	C	6 (Create)

Course Outline

Introduction and Overview, Abstract Data Type, Arrays, Stacks(Push and Pop), Infix, Postfix and Prefix, Basic Operations, Queues(Insertion, Deletion, De-queues), Heap, Lists, Linked Lists, Searching(Binary and Sequential), Sorting, Sorting and Hashing, Recursion, Trees, Linked Lists Implementation, Binary Trees, B-Trees, Trees Traversal, Basic Operations, Traversals Sets, Graph, Representation of Directed and Undirected Graphs, Traversals, Minimum Cost Spanning Tree, Complexity(Space and Time).

Reference Material

The following is the recommended list of books (or their latest editions):

1. Weiss, Mark A. Data Structures and Algorithm Analysis in Java. 3rd Edition., Pearson, 2014.
2. Carrano, Frank M., and Timothy M. Henry. Data Structures and Abstractions with Java. 5th Edition., Pearson, 2017.
3. Drozdek, Adam. Data Structures and Algorithms in C++. 4th Edition., Cengage Learning, 2018.
4. Weiss, Mark Allen. Data Structures and Algorithm Analysis in C++. 4th Edition., Pearson, 2014.

5. Lewis, John, and Joseph Chase. Java Software Structures: Designing and Using Data Structures. 4th Edition., Pearson, 2014.

Course Name:	**Database Systems**
Course Code:	CS121
Course Area:	Computing Core
Credit Hours:	4 (3-3)
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 modelling and DBMS concepts.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand fundamental database concepts	C	2 (Understand)
CLO-2	Design conceptual, logical and physical database schemas using different data models.	C	6 (Create)
CLO-3	Understand and identify functional dependencies and resolve database anomalies by normalizing database tables.	C	2 (Understand)
CLO-4	Understand and use Structured Query Language (SQL) for database definition and manipulation in any DBMS	C	2 (Understand) & 3(Apply)

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, selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Structured Query Language (SQL), Joins and sub- queries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, NoSQL systems.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Connolly, Thomas, and Carolyn Begg. Database Systems: A Practical Approach to Design, Implementation, and Management. 6th Edition., Pearson, 2015.

2. Garcia-Molina, Hector, Jeffrey D. Ullman, and Jennifer Widom. Database Systems: The Complete Book. 2nd Edition., Pearson, 2008.
3. Silberschatz, Avi, Henry Korth, and S. Sudarshan. Database System Concepts. 6th Edition., McGraw-Hill Education, 2019.
4. Ramakrishnan, Raghu, and Johannes Gehrke. Database Management Systems. 3rd Edition., McGraw-Hill Education, 2008.

Course Name:	**Information Security**
Course Code:	CS203
Course Area:	Computing Core
Credit Hours:	3 (2-3)
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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Explain key concepts of information security such as design principles, cryptography, risk management, and ethics	C	1 (Remember)
CLO-2	Discuss legal, ethical, and professional issues in information security	C	2 (Understand)
CLO-3	Apply various security and risk management tools for achieving information security and privacy	C	3 (Apply)
CLO-4	Identify appropriate techniques to tackle and solve problems in the discipline of information security	C	4 (Analyze)

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 Material

The following is the recommended list of books (or their latest editions):

1. Stallings, William. Computer Security: Principles and Practice. 3rd Edition., Pearson, 2017.
2. Whitman, Michael E., and Herbert J. Mattord. Principles of Information Security. 6th Edition., Cengage Learning, 2021.
3. Gollmann, Dieter. Computer Security. 3rd Edition., Wiley, 2016.
4. Easttom, William. Computer Security Fundamentals. 3rd Edition., Pearson, 2020.

Course Name:	**Artificial Intelligence**
Course Code:	CS201
Course Area:	Computing Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Object Oriented Programming

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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand the fundamental constructs of Python programming language	C	2 (Understand)
CLO-2	Understand key concepts in the field of artificial intelligence	C	2 (Understand)
CLO-3	Implement artificial intelligence techniques and case studies	C	3 (Apply)

Course Outline

An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min-max algorithm, Alpha beta pruning, Game-playing); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learning from examples; 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 Material

The following is the recommended list of books (or their latest editions):

1. Russell, Stuart, and Peter Norvig. Artificial Intelligence: A Modern Approach. 3rd Edition. Prentice Hall, 2015.
2. Norvig, Peter. Paradigms of Artificial Intelligence Programming: Case Studies in Common Lisp. Morgan Kaufmann, 1992.
3. Joshi, Pratap. Artificial Intelligence with Python. Packt Publishing, 2017.
4. Miller, Bruce N., David L. Ranum, and Jessica Anderson. Python Programming in Context. 1st Edition. Jones & Bartlett Learning, 2019.

Course Name:	**Computer Networks**
Course Code:	CS206
Course Area:	Computing Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction

This course familiarizes the students with the fundamental concepts of computer networks, its components and design. The focus is on the data link, network and transport layers. The course discusses the design, working and different protocols working on these layers.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand the key terminologies and technologies of computer networks	C	2 (Understand)
CLO-2	Understand the services and functions provided by each layer in the Internet protocol stack.	C	2 (Understand)
CLO-3	Identify various internetworking devices and protocols and their functions in a networking, Analyze working and performance of key technologies, algorithms and protocols	C	4 (Analyze)
CLO-4	Build Computer Network on various Topologies	P	3(Build)

Course Outline

Networking Concepts, Topologies: Bus, Star, Ring, Tree, Mesh, Need of Networks, Peer- to-Peer networks, Client- Server Networks, Hybrid Networks, Network Models, TCP/IP Model, OSI Model, Data Link Layer, Error Detection/Correction & Control Techniques, Error Control Techniques, Stop and Wait ARQ, Go-Back-N ARQ, Selective-Reject ARQ, High Level Data Link Control Protocols (HDLC, Stop & Wait, Sliding Window, Access Techniques, Random Access techniques, Aloha, Slotted Aloha, CSMA, CSMA/CD, Controlled Access Techniques, Reservation, Token Passing , Internetworking Devices, Hubs, Switches, Routers. NICs, Switching Techniques, Circuit and Packet Switching, Message Switching, Structure of a Switch, LAN Architectures, Wired LANs, IEEE Standards, Ethernet, Fast and Gigabit Ethernet, Logical Addressing, IPv4 and IPv6 Addressing and Packet Structure, Transition from IPv4 to IPv6, ICMPv6, IGMP, Forwarding and Routing, Unicast and Multicast Routing Protocols, UDP, TCP and SCTP Protocols, Fundamentals of

DNS, FTP, SMTP, WWW, HTTP and SNMP Protocols.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Stallings, William. Data and Computer Communications. 8th Edition., Prentice Hall, 2007.
2. Forouzan, Behrouz A. Data Communications and Networking. 4th Edition., McGraw-Hill, 2007.
3. Tanenbaum, Andrew S. Computer Networks. 4th Edition., Prentice Hall, 2003.
4. Forouzan, Behrouz A., and Firouz Mosharraf. Computer Networks: A Top-Down Approach. McGraw-Hill, 2012.

Course Name:	**Software Engineering**
Course Code:	CS204
Course Area:	Computing Core
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction

The students will be provided with a more concise description of state-of-the-art software process models and application of software engineering concepts as used in a professional software development environment. This course covers advanced theoretical concepts in software engineering and provides extensive hands-on experience in dealing with various issues of software development. It involves a semester-long group software development project. Emphasis will be placed on agile software development methodologies for team development, quality assessment, and knowledge management in software engineering.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand various software engineering processes and activates	C	2 (Understand)
CLO-2	Apply the system modeling techniques to model a medium size software system	C	3 (Apply)
CLO-3	Apply software quality assurance and testing principles to medium size software systems	C	3 (Apply)

Course Outline

Professional software development, Software engineering practices, Software process structure, Traditional software process models, Agile software development, Agile process models(XP, Scrum), Agile development practices, Requirements engineering process, Functional and non-functional requirements, Model driven engineering, UML diagrams: Context models, Interaction models, Structural models, behavioral models, , Architectural design, Detailed design and implementation, , Design patterns, Coding standards, Software testing and quality assurance, Software deployment, maintenance, evolution, Overview of

project management(Introduction to MS Project or related tool) Introduction to software development, environment (Concepts of Build, Continuous Integration/Continuous delivery, Configuration management (GitHub, GitLab, etc)

Reference Material

The following is the recommended list of books (or their latest editions):

1. Sommerville, Ian. Engineering Software Products: An Introduction to Modern Software Engineering. United Kingdom, Pearson, 2020
2. Mall, Rajib. Fundamentals of Software Engineering, Fourth Edition. Phi Learning, 2018.
3. Martin, Robert C. Clean Code. Pearson Education, 2009.
4. Stephens, Rod. *Beginning Software Engineering*. John Wiley and Sons, 2022
5. Amuthabala, K., et al. *Agile Software Development - An Overview*. MileStone Research Publications, 2023,

Course Name:	**Computer Organization and Assembly Language**
Course Code:	CS207
Course Area:	Computing Core
Credit Hours:	3 (2-3)
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. At the end, students should be able to write moderately assembly language subroutines and interfacing them to any high-level language.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Acquire basic knowledge of computer organization, architecture & assembly language	C	2 (Understand)
CLO-2	Understand the concepts of basic computer organization, architecture, and assembly language techniques	C	2 (Understand)
CLO-3	Solve the problems related to computer organization and assembly language	C	3 (Apply)

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 Material

The following is the recommended list of books (or their latest editions):

1. Patterson, David A., and John L. Hennessy. Computer organization and Design. 5th Edition. Morgan Kaufmann, 2013.
2. Mano, M. Morris. Computer system architecture. 3rd Edition. Prentice-Hall, Inc., 1993.
3. Duntemann, Jeff. Assembly language step-by-step: Programming with Linux. 3rd Edition. John Wiley & Sons, 2011.
4. Bryant, Randal E., and David Richard O'Hallaron. Computer systems: a programmer's perspective. 3rd Edition. Prentice Hall, 2016.
5. Britton, Robert. MIPS assembly language programming. 2003.

Course Name:	**Operating Systems**
Course Code:	CS208
Course Area:	Computing Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Data Structures

Course Introduction

This course will introduce the core concepts of operating systems, such as processes and threads, scheduling, synchronization, memory management, file systems, input and output device management and security. The course will consist of assigned reading, weekly lectures, a midterm and final exam, and a sequence of programming assignments. The goal of the readings and lectures is to introduce the core concepts. The goal of the programming assignments is to

give students some exposure to operating system code. Students are expected to read the assigned materials prior to each class, and to participate in in-class discussions.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems	C	2 (Understand)
CLO-2	Analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues regarding the core functions	C	4 (Analyze) & 5 (Evaluate)
CLO-3	Demonstrate the knowledge in applying system software and tools available in modern operating systems.	C	3 (Apply)

Course Outline

Introduction & Overview, Computer Organization, Interrupts, Components of Operating System, Processes & PCB, Process Creation, Process Management, Processes, Process States, Process State Models, Inter-Process Communication, Process Scheduling, Threads, Synchronization Issues, Busy Waiting Algorithm &Bakery Algorithm, TSL & Priority Inversion, Semaphores, Classical Synchronization Problems, Dead Locks, Deadlock Detection, Deadlock recovery, Deadlock Avoidance, Deadlock Prevention, Memory management, Real Memory Organization and Management, Virtual Memory Organization: Paging, Segmentation, Virtual Memory Management: Placement, Replacement, and Fetch Strategies Input Output Management, File System.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Abraham, Silberschatz, Gagne Greg, and Galvin Peter Baer. Operating System Concepts, 10th Edition. 2018.
2. Tanenbaum, Andrew. Modern operating systems, 5th.Edition. Pearson Education, Inc, 2023.
3. Ritchie, Colin. Operating Systems, 3rd Edition. Continuum, 2000.

Course Name:	**Analysis of Algorithms**
Course Code:	CS205
Course Area:	Computing Core
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.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm. Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors	C	2 (Understand)
CLO-2	Determine informally the time and space complexity of simple algorithms. Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms. Use of the strategies (brute-force, greedy, divide-and- conquer, and dynamic programming) to solve an appropriate problem	C	3 (Apply)
CLO-3	List and contrast standard complexity classes	C	4 (Analyze)
CLO-4	Solve problems using graph algorithms, including single- source and all-pairs shortest paths, and at least one minimum spanning tree algorithm. Trace and/or implement a string-matching algorithm	C	5 (Evaluate)

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 Material

The following is the recommended list of books (or their latest editions):

1. Cormen, Thomas H., et al. Introduction to algorithms. 4th Edition. MIT press, 2022.
2. Kleinberg, Jon, and Eva Tardos. Algorithm design. Pearson Education India, 2013/2014
3. Sedgewick, R., and K. Wayne. Algorithms 4th Edition, 2021.Acessoem, 2023.

3.2 AI Domain Core Courses

This AI Domain Core area consists of 6 courses, comprising 18 credit hours, as outlined below:

Course Name:	**Programming for Artificial Intelligence**
Course Code:	CS308
Course Area:	Domain Core
Credit Hours:	4 (3-3)

Contact Hours: 3-3
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 ultimate aim of this course is to help students in using the AI programming languages to solve problems of interest to them.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	**Level**
CLO 1	Understand the fundamental constructs of Lisp, Prolog, and Python programming languages.	C	2 (Understand)
CLO 2	Comprehend the fundamental constructs of programming languages for data analysis and representation	C	1 (Remember)
CLO 3	Understand and apply the Object-oriented concepts in the programming languages.	C	2 (Understand)
CLO 4	Apply various libraries for plotting, interpreting and analyzing data in Python.	C	3 (Apply)

Course Outline

The first objective of the course is to introduce and then build the proficiency of students in different 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 Material

The following is the recommended list of books (or their latest editions):

1. Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach, 4th Edition. Pearson, Prentice Hall, Inc., 2016.
2. Luger, George F., and William A. Stubblefield. AI algorithms, data structures, and idioms in Prolog, Lisp, and Java, 1st Edition. Pearson Addison-Wesley, 2009.

3. Severance, Charles. Python for everybody: Exploring data using Python 3. 3rd Edition. CreateSpace Independent Publ Platform, 2016.
4. Miller, Bradley N., David L. Ranum, and Julie Anderson. Python programming in context, 2nd Edition. Jones & Bartlett Learning, 2019.
5. McKinney, Wes. Python for data analysis, 3rd Edition " O'Reilly Media, Inc.", 2022.
6. Joshi, Prateek. Artificial intelligence with python, 2nd Edition. Packt Publishing Ltd, 2017.
7. Janert, Philipp K. Data analysis with open source tools: a hands-on guide for programmers and data scientists, 1st Edition. " O'Reilly Media, Inc.", 2010.

Course Name:	**Machine Learning**
Course Code:	CS307
Course Area:	Domain Core
Credit Hours:	3(2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

Course Introduction

This course provides the overview of machine learning along with various learning tasks. Topics include: Overview of Machine Learning; Supervised Learning; Unsupervised Learning; Reinforcement Learning; and Deep Learning.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Overview of machine learning	C	1 (Remember)
CLO 2	Supervised, unsupervised and reinforcement Learning	C	2 (Understand)
CLO 3	Implementation of ML algorithms using real world dataset	C	3 (Apply)

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; Semisupervised learning with EM using labeled and unlabled 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 Material

The following is the recommended list of books (or their latest editions):

1. Alpaydin, Ethem. Introduction to machine learning, 4th Edition, MIT press, 2020.
2. Mitchell, Tom. M. Machine Learning, 1st Edition. McGraw Hill, 1997.
3. James, Gareth, et al. An introduction to statistical learning, 2nd edition. Vol. 112. New York: springer, 2013.
4. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow, 3rd edition. " O'Reilly Media, Inc.", 2022

Course Name:	**Artificial Neural Network and Deep Learning**
Course Code:	CS315
Course Area:	Domain Core
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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Understand the fundamentals of neural networks in AI and Explain how simple ANNs can be designed	C	2 (Understand)
CLO 2	Apply ANN for classification Problems and deep learning algorithms to real-world problems	C	3 (Apply)
CLO 3	Analyze results from deep learning to select appropriate solutions	C	3 (Apply)

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 Material

The following is the recommended list of books (or their latest editions):

1. Jesús, O. D., et al. Neural Network Design. 2nd Edition., Martin Hagan, 2014.
2. Anderson, James A. An Introduction to Neural Networks. 1st Edition., MIT Press, 1995.
3. Hassoun, Mohamad H. Fundamentals of Artificial Neural Networks. 1st Edition., MIT Press, 2003.
4. Bengio, Yoshua, Ian Goodfellow, and Aaron Courville. Deep Learning. Vol. 1, 1st Edition., MIT Press, 2016.
5. Chollet, Francois. Deep Learning with Python. 2nd Edition., Simon and Schuster, 2021.

Course Name:	**Knowledge Representation and Reasoning**
Course Code:	CS331
Course Area:	Domain Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
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.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Understand the fundamentals of knowledge representation and reasoning in deterministic situations	C	2 (Understand)
CLO 2	Understand the challenges in representing knowledge and reasoning under uncertainty	C	3 (Apply)
CLO 3	Analyze results from deep learning to select appropriate solutions	C	3 (Apply)

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 Material

The following is the recommended list of books (or their latest editions):

1. Russell, Stuart J., and Peter Norvig. Artificial Intelligence: A Modern Approach. 3rd Edition., Pearson, 2016.
2. Poole, David L., and Alan K. Mackworth. Artificial Intelligence: Foundations of Computational Agents. 2nd Edition., Cambridge University Press, 2017.
3. Brachman, Ronald, and Hector Levesque. Knowledge Representation and Reasoning. 1st Edition., Morgan Kaufmann, 2004.

Course Name:	**Computer Vision**
Course Code:	CS328
Course Area:	Domain Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Applied Linear Algebra, Programming Fundamentals

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 modelling from single view and multiple views.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO 1	Understanding the single view geometry concepts	C	2 (Understand)
CLO 2	Understanding the multiple view geometry concepts	C	2 (Understand)
CLO 3	Apply concepts of CV for solving real world problems	C	3 (Apply)

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 Material

The following is the recommended list of books (or their latest editions):

1. Szeliski, Richard. Computer Vision: Algorithms and Applications. 2nd Edition., Springer, 2022.
2. Hartley, Richard, and Andrew Zisserman. Multiple View Geometry in Computer Vision. 2nd Edition., Cambridge University Press, 2003.
3. Forsyth, David A., and Jean Ponce. Computer Vision: A Modern Approach. 2nd Edition., Prentice Hall Professional Technical Reference, 2002.
4. Gonzalez, Rafael C. Digital Image Processing. 4th Edition., Pearson Education India, 2009.

Course Name:	**Parallel and Distributed Computing**
Course Code:	CS403
Course Area:	Domain Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Object Oriented Programming, Operating Systems

Course Introduction

In this course student will learn about parallel and distributed computers. They will be able to write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library with analytical modeling and performance of parallel programs. They can also analyze complex problems with shared memory programming with OpenMP.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Learn about parallel and distributed computers.	C	1 (Remember)
CLO 2	Coding programs for parallel or distributed architectures using Message-Passing Interface (MPI) library	C	3 (Apply)
CLO 3	Analyze complex problems with shared memory programming with openMP.	C	4 (Analyze)

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 Material

The following is the recommended list of books (or their latest editions):

1. Tanenbaum, Andrew S., and Maarten Van Steen. Distributed Systems: Principles and Paradigms. 2nd Edition., Pearson, 2007.
2. Hwang, Kai, J. J. Dongarra, and Geoffrey C. Fox. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet. 1st Edition., Morgan Kaufmann, 2011.

3.3 AI Domain Elective Courses

This AI Domain Elective area consists of 7 courses, comprising 21 credit hours, as outlined below:

Course Name:	**Natural Language Processing**
Course Code:	CS420
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

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.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Understand techniques for information retrieval, language translation, and text classification	C	2 (Understand)
CLO 2	Language Modeling	C	6 (Create)
CLO 3	Understand and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each	C	2 (Understand)
CLO 4	Solve classic and stochastic algorithms for parsing natural language.	C	3 (Apply)

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 Material

The following is the recommended list of books (or their latest editions):

1. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing. 3rd Edition. Prentice Hall, 2018.
2. Manning, Christopher, and Hinrich Schutze. Foundations of statistical natural language processing. 3rd Edition. MIT Press, 1999.
3. Bird, Steven, Ewan Klein, and Edward Loper. Natural language processing with Python: analyzing text with the natural language toolkit. 1st Edition. O'Reilly Media, Inc., 2009.

Course Name:	**Speech Processing**
Course Code:	CS345
Course Area:	Domain Electives
Credit Hours:	3(2-3)
Contact Hours:	2-3
Pre-requisites:	Probability and Statistics, Applied Linear Algebra

Course Introduction

This course covers the basic and essential knowledge involved in Speech Processing, which is a field of Artificial Intelligence. This course is divided into two sub-parts: speech recognition and speech generation (synthesis). The course covers relevant theory related to speech as a signal that carries information, how speech is produced and how it is perceived by computers. Students will not only learn an essential part of artificial intelligence in this course, but also the latest models and technologies involved in it with respect to the industry.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	**Level**
CLO 1	Understand speech generation and speech recognition	C	2 (Understand)
CLO 2	Apply speech generation and recognition algorithms and models	C	3 (Apply)
CLO 3	Design representative features and models for speech processing	C	6 (Create)

Course Outline

Introduction to Speech Processing (Speech Recognition, Speech Synthesis). Phonetics, Phonemes, International Phonetic Alphabet (IPA), Transcription, Acoustics of Consonants and Vowels, Speech Signal and Sine Waves, Waveform Generation, Connected Speech, Feature Engineering, Speech Attributes, Fast Fourier Transforms, Spectrograms, Formants, Hidden Markov Models (HMMs), Gaussian Mixture Models (GMMs), Pattern Matching, Python Libraries for Speech Processing

Reference Material

The following is the recommended list of books (or their latest editions):

1. Jurafsky, Daniel, and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing. 3rd Edition. Prentice Hall, 2018.
2. Yu, Dong, and Lin Deng. Automatic Speech Recognition. 1st Edition. Berlin: Springer, 2016.
3. Benesty, Jacob, M. Mohan Sondhi, and Yiteng Huang. Springer Handbook of Speech Processing. 1st Edition. Berlin: springer, 2017.

Course Name:	**Data Mining**
Course Code:	CS318
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Probability and Statistics, Artificial Intelligence

Course Introduction

Data Mining has emerged at the confluence of artificial intelligence, statistics, and databases as a technique for automatically discovering hidden patterns in large datasets. The main purpose of this course is the ability to analyze and construct knowledge from data to achieve an understanding of the development of Classification, Prediction, and Clustering applications.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Apply preprocessing techniques on any given raw data.	C	3 (Apply)
CLO 2	Select and apply proper data mining algorithm to discover interesting patterns	C	2 (Understand)
CLO 3	Analyze and extract patterns to solve problems and point out how to deploy solution	C	4 (Analyze)
CLO 4	Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy	C	5 (Evaluate)

Course Outline

Introduction to data mining and basic concepts, Pre-Processing Techniques & Summary Statistics, Association Rule mining using Apriori Algorithm and Frequent Pattern Trees, Introduction to Classification Types, Supervised Classification (Decision trees, Naïve Bae Classification, K-Nearest Neighbors, Support Vector Machines etc.), Unsupervised Classification (K Means, K Median, Hieratical and Divisive Clustering, Kohonan Self Organizing maps), outlier & anomaly detection, Web and Social Network Mining, Data Mining Trends and Research Frontiers. Implementing concepts using Python

Reference Material

The following is the recommended list of books (or their latest editions):

1. Han, Jiawei, Micheline Kamber, and Jian Pei. "Data Mining: Concepts and Techniques, 3rd Edition.Waltham: Morgan Kaufmann Publishers 2012.
2. Tan, Pang-Ning, Michael Steinbach, and Vipin Kumar. "Introduction to Data Mining." 2nd Edition. Pearson, 2018.
3. Aggarwal, Charu C. Data mining: the textbook, 1st Edition. New York: springer, 2015.
4. Hand, D., Heikki Mannila, and Padhraic Smyth. Principles of Data Mining, 4th Edition. The MIT Press 2001.

Course Name:	Advanced Statistics

Course Code:	CS302
Course Area:	Domain Electives
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Probability and Statistics

Course Introduction

Statistical methods are used for analysis of different datasets for forecasting the values, predicting the unknowns, relating the variables for getting deeper insights and relating data differences with real world complexities. Data Science extracts knowledge from data on the basis of hidden patterns which can be made explicit by incorporating the statistical algorithms in it. This course is designed to prepare students on statistical techniques with a purview of artificial intelligence and data science.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	**Level**
CLO 1	Describe what part of statistics is meant for data scientist and what the applications of statistics in data science are.	C	2 (Understand)
CLO 2	Apply Statistical techniques in real life problems.	C	3 (Apply)
CLO 3	Analyze, Correlate, Forecast data by using different statistical techniques	C	4 (Analyze)
CLO 4	Apply basic data science statistical techniques by using SPSS on real world datasets.	C	3 (Apply)

Course Outline

Introduction to Statistics, Use of Statistics in Data Science, Experimental Design, Statistical Techniques for Forecasting, Interpolation/ Extrapolation, Introduction to Probability, Conditional Probability, Prior and Posterior Probability, Random number generation (RNG), Techniques for RNG, Correlation analysis, Chi Square Dependency tests, Diversity Index, Data Distributions Multivariate Distributions, Error estimation, Confidence Intervals, Linear transformations, Gradient Descent and Coordinate Descent, Likelihood inference, Revision of linear regression and likelihood inference, Fitting algorithms for nonlinear models and related diagnostics, Generalized linear model; exponential families; variance and link functions, Proportion and binary responses; logistic regression, Count data and Poisson responses; log-linear models, Overdispersion and quasi-likelihood; estimating functions, Mixed models, random effects, generalized additive models and penalized regression; Introduction to SPSS, Probability/ Correlation analysis/ Dependency tests/ Regression in SPSS.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Baron, Michael. Probability and Statistics for Computer Scientists. 2nd Edition., Chapman and Hall/CRC, 2019.
2. Forsyth, David. Probability and Statistics for Computer Science. Online Edition., vol. 13, Springer International Publishing, 2018.
3. Field, Andy. Discovering Statistics Using IBM SPSS Statistics. 5th Edition., Sage Publications, 2024.

Course Name:	**Reinforcement Learning**
Course Code:	CS343
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Machine Learning

Course Introduction

This course will provide a broad introduction to the foundational concepts and algorithms of reinforcement learning, one of the largest and most active areas in machine learning. The main focus will be on fundamental algorithms and their applications, and will end with an introduction to deep reinforcement learning. Knowledge of probability theory, logic, expectation, and basic machine learning principles (e.g., gradient descent) will be very helpful.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Define the core features of reinforcement learning, and explain how RL differs from other machine learning approaches	C	2 (Understand)
CLO 2	Determine if a given problem should be approached as a reinforcement learning problem. Compare different algorithms to select the most appropriate for a particular application/problem space.	C	4 (Analyze)
CLO 3	Implement (in code) various common/classic reinforcement algorithms from scratch in Python.	C	3 (Apply)

Course Outline

Introduction and Motivation , Markov Processes and MDPs , Value Iteration and Policy Iteration , Introduction to RL , Deep Neural Networks , Deep Q-Networks , Policy Gradient,

Actor-Critic Method , Revisit – Multi-Armed Bandit , Model Based RL , Imitation RL, Inverse RL.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction, 2nd Edition MIT press, 2018.
2. Sewak, Mohit. Deep reinforcement learning, 1st Edition Singapore: Springer Singapore, 2019.

Course Name:	**Theory of Automata**
Course Code:	CS311
Course Area:	Domain Electives
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Object Oriented Programming

Course Introduction

This course serves as an introduction to the basic theory of Computer Science and formal methods of computation. This course will present the theory of finite automata, as the first step towards learning advanced topics, such as compiler design. It will also enable the student to apply the concepts learned in fundamental courses such as Discrete Mathematics, in a theoretical setting; in particular, the application of proof techniques. The applications of finite automata towards text processing will be discussed. This course will also develop an understanding of computation through Turing Machines.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand the working of computer at abstract level.	C	2 (Understand)
CLO-2	Design software and some electronic circuits.	C	3 (Apply)
CLO-3	Understand the basic theory behind computer languages.	C	2 (Understand)
CLO-4	Have a sound background for translator software.	C	1 (Remember)

Course Outline

Introduction to Language: Language as a set, string, string terminologies, alphabet, operations on languages (Union, Concatenation, Kleene Closure), Language Representation: Recursive Definition, Regular Expression (Basic Regular Expressions, Complex Regular Expressions using notational short hands), Grammars, Automata Introduction: What is Automata? Types of Automata, Parts of Automata, Determinism, Finite Automata (FA): Definition of FA, Elements of FA, Nondeterministic Finite Automata (NFA), Deterministic Finite Automata (DFA),

Working of FA, Regular Expression to NFA conversion, NFA to DFA conversion, Minimization of number of states in a DFA, DFA coding in C language, Kleene's Theorem: Transition Graph (TG), Generalized Transition Graph (GTG), Statement and Proof of Kleene's Theorem, Finite Automata With output: Moore Machine, Mealy Machine, Moore=Mealy, Context Free Grammars: Definition, Derivation, Problems in Context Free Grammars (Ambiguity, Left Recursion, Common Prefixes), Methods for removal of these problems, Chomsky Normal Form (CNF), Pushdown Automata (PDA): Definition of PDA, Elements of PDA, Creation of PDA i.e. CFG=FA, Touring Machines: Definition of Turing Machines, Elements of Turing Machines, Creation of Turing Machines, Pumping Lemma.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Cohan, Daniel I. Introduction to Computer Theory. 2nd Edition., John Wiley & Sons, 1997.
2. Kellye, Daniel. Automata and Formal Languages: An Introduction. 1st Edition., Prentice Hall, 1998.
3. Spiser, Michael. Theory of Computation. 1st Edition., Cengage Learning, 2007.

Course Name:	**Human Computer Interaction**
Course Code:	CS319
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Programming Fundamentals

Course Introduction

This course is designed to provide students with a comprehensive introduction to the field of Human Computer Interaction (HCI). This course aims to impart foundational knowledge in order to design useful interactive systems based on the needs and the context of the use of the interactive systems. The course covers topics about the design process and the design principles that should be considered while designing interactive systems that would provide good a user experience. This course helps to understand the concept of evaluating designs and prototypes using different evaluation techniques with the assistance of experts and users.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Capabilities of humans and computers that can be utilized while designing interactive systems.	C	1 (Remember)
CLO-2	Understand the process of interaction and causes of problems during interactions.	C	2(Understand)
CLO-3	Understand the process of designing interactive systems.	C	2(Understand)

CLO-4	Awareness and application of design principles for improved user experience. Awareness of different evaluation techniques to evaluate designs.	C	3(Apply)

Course Outline

Introduction to the field of HCI, The Human Factor, The Computer Factor, The Interaction, Models of Interaction, Interaction Paradigms, Interaction Design Basics and the design process, Personas, Scenarios Introduction to Wireframes and Prototypes, Design Principles, Principles to Support Usability, Principles of Learnability, Principles of Learnability, Flexibility and Robustness, Shneiderman's Eight golden rules, Nielsen's heuristics, Introduction to Evaluation, Evaluation Techniques, Experts Evaluations, Cognitive walkthrough, Heuristic evaluation, Evaluating through user participation, Laboratory Evaluation, Field Evaluation, Observational techniques, Query techniques, and Think-Aloud techniques, Usability Testing, Contemporary topics and issues, Conducting Experimental, Understanding and the process of A/B Testing.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Dix, Alan, and Russell Beale. Human-Computer Interaction. 3rd Edition., Prentice Hall, 2003.
2. Rogers, Yvonne, Helen Sharp, and Jenny Preece. Interaction Design: Beyond Human-Computer Interaction. 6th Edition., Wiley & Sons, 2023.
3. Shneiderman, Ben, and Catherine Plaisant. Designing the User Interface: Strategies for Effective Human-Computer Interaction. 6th Edition., Pearson, 2016.

Course Name:	**Fuzzy Systems**
Course Code:	CS337
Course Area:	Domain Electives
Credit Hours:	3
Contact Hours:	3-3
Pre-requisites:	Artificial Intelligence

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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Understand basic problem solving using Fuzzy logic	C	2 (Understand)
CLO 2	Design and implement Fuzzy systems	C	3 (Apply)

CLO 3	Application of Fuzzy systems in particular domain	C	6 (Create)

Course Outline

The basic concepts of type-1, 2 fuzzy sets (membership, cardinality, normality), set operations (union, intersection, complementation), distances between fuzzy sets (Hamming distance, normalized Hamming distance, Euclidean distance, normalized Euclidean distance), similarity measures, fuzzy relation and composition, fuzzy number, fuzzy function, probability and possibility, fuzzy logic, linguistic variable, fuzzy inference, de-fuzzification, fuzzy control and fuzzy expert systems. Intuitionistic fuzzy sets (IFSs), distances between IFSs, similarity measures between IFSs, level cut sets, IF relation and composition, IF fuzzy number, Triangular norms, soft sets and set operations, Applications of fuzzy systems in semigroups, groups, semi rings, graphs and differential equations.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Chen, Guanrong, and Trung Tat Pham. Introduction to Fuzzy Systems. 1st Edition., Chapman and Hall/CRC, 2005.
2. Zimmermann, Hans-Jürgen. Fuzzy Set Theory and Its Application. 4th Edition., Springer, 2001.
3. Mordeson, John N., and Davender S. Malik. Fuzzy Semigroups. 1st Edition., Springer, 2010.
4. Zadeh, Lotfi A., King-Sun Fu, Masamichi Tanaka, and Masaki Shimura. Fuzzy Sets and Their Applications to Cognitive and Decision Processes. 1st Edition., Academic Press, 1975.
5. Mordeson, John N., Kiran R. Bhutani, and Azriel Rosenfeld. Fuzzy Group Theory. 1st Edition., Springer, 2010.
6. Atanassov, Krassimir T. Intuitionistic Fuzzy Sets: Theory and Applications. 1st Edition., Springer, 2012.

Course Name:	**Evolutionary Algorithms**
Course Code:	CS346
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

Course Introduction

This course is designed to present an overview of Evolutionary Intelligence (EI) topic, including both behavioral Evolutionary Intelligence and computational swarm intelligence, and applications of EI. 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.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Knowledge of individual/intelligent agents for modeling of industrial, social and biological systems.	C	1 (Remember)
CLO 2	Modeling swarms/social agents in complex landscapes	C	3 (Apply)
CLO 3	Knowledge of evolutionary intelligence algorithms inspired by different natural systems	C	2 (Understand)

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,Multi-robot path planning, Task scheduling.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Engelbrecht, Andries P. Fundamentals of Computational Swarm Intelligence. 2nd Edition., Wiley, 2015.
2. Slowik, Adam. Swarm Intelligence Algorithms: A Tutorial. 1st Edition., CRC Press, 2020.
3. Sun, Jun, Choi-Hong Lai, and Xiao-Jun Wu. Particle Swarm Optimization: Classical and Quantum Perspectives. 1st Edition., CRC Press, 2019.

Course Name:	**Agent Based Modeling**
Course Code:	CS404
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

Course Introduction

This course introduces the principles and techniques of agent-based modeling (ABM), a computational approach for simulating the actions and interactions of autonomous agents to assess their effects on the system as a whole. The course covers the theory behind ABM, practical modeling techniques, and applications in various domains such as social sciences, economics, and biology. Students will gain hands-on experience in designing, implementing, and analyzing agent-based models using appropriate software tools.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Principles and techniques of agent-based modeling	C	1 (Remember)
CLO 2	Computational approaches for simulating the actions and interactions of autonomous agents	C	3 (Apply)
CLO 3	Designing, implementing, and analyzing agent-based models	C	6 (Create)

Course Outline

Introduction to Agent-Based Modeling, Definition and history of ABM, Comparison with other modeling approaches, Overview of ABM applications Fundamental Concepts, Agents and environments, Agent behaviors and interactions, Emergence and complex systems Designing Agent-Based Models, Identifying agents and their attributes, Defining rules and behaviors, Setting up the environment Implementing Agent-Based Models, Introduction to ABM software tools, Hands-on practice with a simple ABM project Advanced Modeling Techniques, Incorporating randomness and stochastic processes, Implementing agent communication and collaboration, Modeling adaptive and learning agents Case Studies in Social Sciences, ABM in sociology and anthropology, Modeling social networks and group behavior, Analyzing social phenomena with ABM Case Studies in Economics, ABM in market dynamics and financial modeling, Simulating economic policies and their impacts, Exploring agent-based computational economics Case Studies in Biology, ABM in ecology and population dynamics, Modeling biological systems and behaviors, Applications in epidemiology and disease spread Model Verification and Validation, Techniques for verifying ABM implementations, Methods for validating model outputs, Sensitivity analysis and robustness testing Data Analysis and Interpretation, Analyzing simulation results, Visualizing agent behaviors and system dynamics, Interpreting findings and drawing conclusions Scalability and Performance Optimization, Techniques for improving model efficiency, Dealing with large-scale simulations, Parallel computing and distributed simulations.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Railsback, Steven F., and Volker Grimm. Agent-Based and Individual-Based Modeling: A Practical Introduction. 8th Edition., Princeton University Press, 2019.
2. North, Michael J., and Charles M. Macal. Managing Business Complexity: Discovering Strategic Solutions with Agent-Based Modeling and Simulation. 2nd Edition., Oxford University Press, 2007.
3. Wilensky, Uri, and William Rand. An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo. 1st Edition., MIT Press, 2015.

Course Name:	**Knowledge Based Systems**
Course Code:	CS408
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

Course Introduction

This module aims to develop an in-depth exploration of knowledge-based systems, including their design, implementation, and application. Students will learn about the fundamental principles of knowledge representation, reasoning, and the various technologies used to build intelligent systems that can emulate human decision-making processes.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Understand the core concepts of knowledge representation and reasoning and to learn different methodologies for building knowledge-based systems	C	2 (Understand)
CLO 2	Explore the use of ontologies and semantic web technologies and gain hands-on experience in developing and deploying knowledge-based systems.	C	2 (Understand)
CLO 3	Analyze case studies and current applications of knowledge-based systems in various domains	C	4 (Analyze)

Course Outline

Introduction to Artificial Intelligence and Knowledge-Based Systems, Definition and history, Applications and examples, Knowledge Representation, Logic-based representation, Frames and semantic networks, Ontologies, Reasoning Techniques, Rule-based reasoning, Case-based reasoning, Model-based reasoning, Inference Mechanisms, Forward chaining, Backward chaining, Probabilistic reasoning, Expert Systems, Data, Information and Knowledge, Types of Knowledge

Design and architecture, Knowledge acquisition, Knowledge engineering, Machine Learning in Knowledge-Based Systems, Integration with knowledge representation, Learning from data, Natural Language Processing and Knowledge Systems, Text mining and information extraction Conversational agents, Ontologies and Semantic Web, RDF, RDFS, and OWL, SPARQL and semantic querying, Applications of Knowledge-Based Systems, Healthcare, Business and finance, Robotics and automation, Ethical and Social Implications, Bias and fairness, Fuzzy logic and Evolutionary algorithms, Privacy and security.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Smith, John. Knowledge-Based Systems, 1st Edition. Jones & Bartlett Learning, 2009.
2. Sowa, John F. Principles of semantic networks: Explorations in the representation of knowledge. 1st Edition, Morgan Kaufmann, 2014.
3. Suárez-Figueroa, Mari Carmen, et al. Introduction: Ontology engineering in a networked world. Springer Berlin Heidelberg, 2012.
4. Brachman, Ronald, and Hector Levesque. Knowledge representation and reasoning. 1st Edition. Morgan Kaufmann, 2004

Course Name:	**Introduction to Robotics**
Course Code:	CS407
Course Area:	Domain Electives
Credit Hours:	3(2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Intelligence

Course Introduction

This course provides an in-depth introduction to the field of robotics, focusing on the principles and technologies that enable the design, development, and operation of robotic systems. Students will explore the fundamental concepts of robotics, including kinematics, dynamics, control systems, sensors, and actuators. Through theoretical lessons and practical lab sessions, students will gain hands-on experience in building and programming robots, preparing them for advanced topics and applications in robotics.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	understanding of the fundamental principles and technologies involved in robotics	C	2 (Understand)
CLO 2	Analyze the components and functioning of robotic systems	C	4 (Analyze)
CLO 3	Design, develop, and implement robotic systems to solve specific problems	C	3 (Apply)
CLO 4	Program robots using appropriate software tools and languages	C	6 (Create)

Course Outline

Understanding and working with robotic systems: definition, history, types, applications of robots, overview of robotic systems and components, mathematical foundations including coordinate systems, transformations, forward and inverse kinematics, Jacobians, dynamics and control principles such as Newton-Euler formulation, Lagrangian dynamics, PID control strategies, various types of sensors (e.g., position, velocity, vision), integration, calibration, control mechanisms of actuators.
Robotic programming languages like Python, C++, ROS, motion planning algorithms, simulation environments, robotic perception involving image processing, computer vision, machine learning techniques, sensor fusion for state estimation, mobile robots (wheeled, legged, aerial types), localization, mapping techniques like SLAM, navigation strategies, robot manipulators, configurations, grasping techniques, industrial applications, human-robot interaction aspects covering user interfaces, safety considerations, ethical implications, collaborative robot applications, future trends, innovations, current research topics, challenges shaping the future of robotics.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Craig, John J. Introduction to robotics. 2nd Edition, Pearson Educacion, 2006.
2. Siciliano, Bruno, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo. Robotics: Modelling, Planning and Control. 1st Edition, Springer, 2009.
3. Spong, Mark W., Seth Hutchinson, and Mathukumalli Vidyasagar. Robot modeling and control. 4th Edition. John Wiley & Sons, 2020.

Course Name:	**Generative Artificial Intelligence**
Course Code:	CS338
Course Area:	Domain Electives
Credit Hours:	3(2-3)
Contact Hours:	2-3
Pre-requisites:	Machine Learning

Course Introduction

This course explores the fundamentals and advanced techniques of Generative AI, an exciting and rapidly evolving field within Artificial Intelligence. Students will delve into the theoretical underpinnings, practical implementations, and applications of generative models, such as Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), and Transformer-based models. The course is designed to equip students with the knowledge and skills required to design, implement, and evaluate generative AI systems, preparing them for careers in AI research and industry.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**

CLO 1	Understand the fundamental concepts and mathematical foundations of generative models.	C	2 (Understand)
CLO 2	Implement and train generative models using popular deep learning frameworks	C	3 (Apply)
CLO 3	Apply generative models to real-world problems, including image synthesis, text generation, and data augmentation	C	3 (Apply)
CLO 4	Demonstrate ethical considerations and understand the societal impacts of generative AI technologies	C	2 (Understand)

Course Outline

Introduction to Generative AI, Applications and impact. Introduction to basic concepts: generative vs. discriminative models, Generative Adversarial Networks (GANs), GAN architecture and components,
Training GANs: loss functions and optimization, Common challenges and solutions (e.g., mode collapse, instability), Advanced GANs and Variants, Conditional GANs, CycleGAN, StyleGAN.
GAN applications: image synthesis, data augmentation, Variational Autoencoders (VAEs), VAE architecture and components, Latent space representation, Training VAEs: ELBO and reparameterization trick, Advanced VAEs and Applications, Conditional VAEs, Applications of VAEs: image generation, anomaly detection.
Transformer-based Generative Models, Introduction to Transformers, GPT, BERT, and their generative capabilities, Training and fine-tuning transformer models, Text Generation with Transformers, Language modeling, Text generation techniques.
Applications: chatbots, story generation, Evaluation of Generative Models, Evaluation metrics for generative models, Visual and quantitative assessment, Human evaluation methods.
Ethical Considerations and Societal Impact, Bias in generative models, Ethical implications of AI-generated content and Discussion on future directions,

Reference Material

The following is the recommended list of books (or their latest editions):

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep Learning. 1st Edition., MIT Press, 2016.
2. Foster, David. Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play. 2nd Edition., O'Reilly Media, 2022.
3. Raschka, Sebastian, Yuxi Hayden Liu, and Vahid Mirjalili. Machine Learning with PyTorch and Scikit-Learn: Develop Machine Learning and Deep Learning Models with Python. 1st Edition., Packt Publishing Ltd, 2022.

Course Name:	**Text Mining**

Course Code:	CS347
Course Area:	Domain Electives
Credit Hours:	3(3-0)
Contact Hours:	3-0
Pre-requisites:	Data Mining

Course Introduction

This course introduces the techniques used for information retrieval using text mining. It discusses the types of text from which the information is to be retrieved and the design of the queries to get the required information.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Introduction to the basics of information retrieval	C	2 (Understand)
CLO 2	Design of queries and use of different optimization techniques	C	3 (Apply)
CLO 3	Measure the performance of information retrieval	C	4 (Analyze)

Course Outline

Overview of text mining, Applications and importance of text mining, Challenges and considerations in text mining, Text Preprocessing: Tokenization and stemming, Stop-word removal, Text normalization techniques, Bag-of-words model, TF-IDF (Term Frequency-Inverse Document Frequency), Word embeddings (e.g., Word2Vec, GloVe), Understanding sentiment analysis, Sentiment lexicons and algorithms, Practical applications of sentiment analysis, Supervised vs. unsupervised classification, Naive Bayes classifier, Support Vector Machines (SVMs) for text classification, Topic modeling, Latent Dirichlet Allocation (LDA), Non-negative Matrix Factorization (NMF), Applications of topic modeling, Introduction to Information Retrieval. Inverted indices and boolean queries. Query optimization. The nature of unstructured and semi-structured text. Query expansion: Wild-card queries, Edit distance, Index construction. Postings size estimation, merge, dynamic indexing, positional indexes. Parametric or fielded search. The cosine measure. Efficiency considerations. Nearest neighbor techniques, Query expansion, Vector space classification using hyperplanes; centroids; k Nearest Neighbors. Text classification. Exploiting text-specific features. Feature selection. Evaluation of classification. Micro- and macro-averaging. Named Entity Recognition (NER) and Future Trends.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.

2. David Foster, "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play," 2nd Edition., O'Reilly Media, 2022.
3. Raschka, Sebastian, Yuxi Hayden Liu, and Vahid Mirjalili. Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python. Packt Publishing Ltd, 2022.

Course Name:	**Computer Architecture**
Course Code:	CS327
Course Area:	Domain Core
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Computer Organization and Assembly Language

Course Introduction

This course covers the basics of modern computer organization and architecture, emphasis on understanding interaction between computer hardware and software at various levels. Students will learn concepts of technology, performance evaluation, instruction set design, ALU, data path and control unit design of processors and pipelining for performance enhancement.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy Domain Level**
CLO-1	Understand the organization of modern computing systems - microprocessor organization and architecture.	C 2 (Understand)
CLO-2	Understand pipelined processor organization & hazards, memory hierarchy & storage devices & multiprocessors.	C2 (Understand)
CLO-3	Perform performance analysis and evaluation.	C4 (Analyze) & 5 (Evaluation)
CLO-4	Apply ALU & control unit implementations, memory hierarchy and multiprocessors.	C3 (Apply)

Course Outline

Computer Architecture and Importance for Computer Science Graduates, Instruction Set Architectures(ISA), Complex Instruction Set Computing (CISC), Reduced Instruction Set Computing (RISC), Operations of the Computer Hardware, Assembly Language, Registers, Data and Instruction Representation, Different Types of Instructions, Loops and IF Statements in Assembly, Supporting Procedures/Functions in Computer Hardware, Supporting Different Data Types in Hardware, Immediate and Addresses in Instructions, Compiling and Linking Processes to Convert a C/Java Program into Assembly and Converting that into Machine Code, Review of Number Systems, Signed and Unsigned Data Types, Arithmetic Operations (Subtraction, Multiplication, Division) in Hardware, Float Data Types and Arithmetic Operations on Float, Evaluating Performance of a System, Latency, Response Time, and Throughput, CPU Execution Time, Calculating CPU Execution Time for a Program,

Benchmarks and Amdahl's Law, Processor Design, Building a 32-bit ALU, Processor Data path, Designing a Processor to Execute Instructions and Include Control Unit, Pipelining and Hazards in Pipelining and Solutions, Memory Hierarchy, Caches, Measuring and Improving Cache Performance, Direct Mapped Cache, Fully Associative Caches and Cache Optimizations, Virtual Memory, Virtual Machines. Storage and other I/O topics, Multiprocessors, Multi-cores and Clusters.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Patterson, David A, and John L Hennessy. Computer Organization and Design: The Hardware/Software Interface. Cambridge, Ma, Morgan Kaufmann Publishers, 2020.
2. Hennessy, John L., and David A. Patterson. Computer Architecture: A Quantitative Approach. Elsevier, 2020.

Course Name:	**Advanced Programming**
Course Code:	CS314
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Object Oriented Programming

Course Introduction

This course comprises of advanced programming topics in the Java programming Language. This course builds on the earlier programming offered on Object Oriented Programming. Advanced concepts of program design, implementation and testing will be introduced within a framework of object-oriented programming using the Java programming language.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand basic OOP and advanced programming concepts using Java programming language	C	2 (Understand)
CLO-2	Design, implement and test multi-threaded, database oriented and network and distributed applications and event driven GUIs	C	3 (Apply)
CLO-3	Understand Java for functional programming	C	2 (Understand)
CLO-4	Create innovative and robust mobile applications that will be valuable addition to their programming portfolio	C	6 (Create)

Course Outline

Java Platform, Java Virtual Machine and Portability, Classes and Object Creation in Java, OOP Concepts in Java, Data Encapsulation and Abstraction, Inheritance and Polymorphism, Abstract Classes and Interfaces in Java, Java Packages, Inner Classes and Usage, Accessing Private Members, Java Collections and Generics , Exception Handling and Importance, Throwing and Catching Exceptions, try-catch-finally Blocks, Threads and Importance, Creating Threads, Starting Threads, Seep, Join, Priority, Daemon Threads, Thread Synchronization and Importance, Sharing Objects Between Threads and Race Conditions, Synchronized Methods and Synchronized Blocks, wait(), notify(), notifyall(), Explicit Locks for Synchronization, features in the Java Concurrent Package, Reading and Writing String Values from a File, Preserving Object State using Serialization, Network Programming, Java Sockets and the java.net package, TCP Based Programming, UDP Based Programming, Sending Objects Over the Network Using Serialization, Java Remote Method Invocation (RMI), Graphical User Interfaces (GUIs), Event Driven Programming and using it with GUIs, Java Database Connectivity (JDBC),Functional Programming and Importance, Lambdas, Data Streams in Java.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Deitel, Paul J, and Harvey M Deitel. Java : How to Program. New York, Pearson, 2019.
2. Schildt, Herbert. Java: A Beginner's Guide, Ninth Edition, 9th Edition. New York, McGraw-Hill, 2022.
3. Schildt, Herbert. Java: The Complete Reference, Twelfth Edition. McGraw Hill Professional, 2021.

Course Name:	**Mobile Application Development**
Course Code:	CS341
Course Area:	Domain Electives
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Advanced Programming

Course Introduction

This course introduces mobile applications programming. The goal of this course is to teach and train students how to design, implement, test, debug and publish smartphone applications on smartphone platforms, especially Android. Students will learn how to take their innovative ideas from conception to the apps market through a series of rigorous hands-on programming

assignments and group projects. This is an introductory course aimed at undergraduate students, who have object-oriented programming experience. However, there is a significant amount of programming in this course requiring a commitment on the part of the student. A key part of this course is group projects where students will work in small teams for joint problem solving.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain Level
CLO-1	Understand aspects of mobile applications programming and uniqueness from programming for other platforms	C2 (Understand) & 4 (Analyze)
CLO-2	Understand mobile applications development for the Android operating system that use basic and advanced phone features	C2 (Understand)
CLO-3	Design, implement, test, debug and publish smartphone applications	C3 (Apply)
CLO-4	Create innovative and robust mobile applications that will be valuable addition to their programming portfolio	C6 (Create)

Course Outline

Android Platform and Architecture, Comparison of Android and Other Platforms, Configuring Development Environment, Activities, Services, Broadcast Receiver, Fragments, Intents, Designing Interface Using Views and Widgets, Layouts, List View, Dialogs and Notification, Menus, Multi-threading, Location and Maps Services, Shared Preferences, Creating and Using Database, Accessing and Handling Sensors, Publishing and Deploying Applications on Android Market.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Horton, John. Android programming for beginners. Packt Publishing Ltd, 2015.
2. Sills, Bryan,
3. Phillips, Bill, and Brian Hardy. Android programming: the big nerd ranch guide. Pearson Education, 2013.
4. Wei-Meng, Lee. "Beginning Android™ 4 Application Development." (2012).
5. Meier, Reto. Professional Android 4 application development. John Wiley & Sons, 2012.

3.4 Mathematics and Supporting Courses

This area of the Mathematics and Supporting Courses consists of 4 courses, totaling 12 credit hours, as outlined below:

Course Name:	Probability and Statistics
Course Code:	
Course Area:	Mathematics & Supporting Courses
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction

Probability has applications in computer science disciplines. This course is intended to fill the gap in students' knowledge of probability.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	**Level**
CLO 1	Measures of Central Tendency and Variation.	C	1 (Remember)
CLO 2	The concept of a Sets, probability, Random Variables and Probability Distribution	C	2 (Understand)
CLO 3	Statistical Inference, Regression and Correlation	C	4 (Analyze)

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, F-Quantile and Probability Plots, Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Square Estimators.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Walpole, Ronald E., Raymond H. Myers, Raymond H. Myers, Raymond H. Myers, Probability and statistics for engineers and scientists. 9th Edition., Pearson, 2011.
2. Hayter, Anthony J. "Probability and statistics for engineers and scientists. 4th Edition., Cengage Learning 2012.

3. Spiegel, Murray R., R. Alu Srinivasan, and John J. Schiller. Schaum's outline of probability and statistics, 4th Edition., McGraw Hill, 2012.
4. Haigh, John. Probability: A very short introduction. Vol. 310. Oxford University Press, 2012.

Course Name:	**Multivariate Calculus**
Course Code:	
Course Area:	Mathematics & Supporting Courses
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Calculus and Analytical Geometry

Course Introduction

This is an extension of single variable calculus. It focuses on the calculus as it applies to functions of two or more variables. The concept learnt in this course will be useful in analyzing geometry of curves and surfaces.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Understand Multivariable Functions	C	2 (Understand)
CLO 2	Compute Multivariable Integrals	C	5 (Evaluate)
CLO 3	Analyze Vector Fields and Line Integrals	C	4 (Analyze)

Course Outline

Calculus of parametric curves, polar coordinates, coordinates and vectors in three-dimensions, dot and cross products, lines and planes in three-dimensions, conic sections and quadratic surfaces, parametric curves in three-dimensions, functions of two and three variables, partial derivatives, tangent planes and differentiability, the chain rule, the gradient and directional derivatives, maxima and minima, Lagrange multipliers, double integrals over rectangles and general regions, double integrals in polar coordinates, applications of double integrals, surface area as double integral, triple integral, cylindrical and spherical coordinates, vector fields and line integrals, Greens theorem, divergence and curl, Stokes theorem, divergence theorem.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Stewart, James, Daniel K. Clegg, Saleem Watson, Multivariable Calculus, 9th Edition., Centage Learning, 2012.
2. Briggs, William, Lyle Cochran, Bernard Gillett, Eric Schulz, Multivariable Calculus, 3rd Edition., Pearson, 2018.

3. Dineen, Seán. Multivariate calculus and geometry, 3rd Edition., Springer-Verlag London, 2014.

Course Name:	**Applied Linear Algebra**
Course Code:	
Course Area:	Mathematics & Supporting Courses
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Calculus and Analytical Geometry

Course Introduction

This elementary course in applied linear algebra prepares students for learning advanced concepts in computer science.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Algebra of linear transformations and matrices	C	2 (Understand)
CLO 2	Systems of Equations	C	1 (Remember)
CLO 3	Eigenvalues and Eigenvectors	C	3 (Apply)

Course Outline

Introduction to Vectors. Solving Linear Equations. Elimination Factorization. Vector Spaces and Subspaces. Orthogonality. Determinants. Eigen values, and Eigenvectors. Linear Transformations. Linear Transformation, Applications of Matrices in Engineering. Graphs and Networks, Marko Matrices, Population, and Economics. Linear Programming. Fourier Series. Linear Algebra for Functions, Linear Algebra for Statistics and Probability, Computer Graphics. Numerical Linear Algebra. Complex Vectors and Matrices. Discrete Transforms and Simple Applications. Cosine Transform, The Discrete Fourier Transform. Simplification and Factorization of the DFT. Matrix. Fast Fourier Transforms. The Discrete Time Fourier Transform.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Strang, Gilbert. Introduction to linear algebra. 5th Edition., Wellesley-Cambridge Press, 2022.
2. Poole, David. Linear algebra: A modern introduction. 4th Edition.,Cengage Learning, (2015.
3. Kolman, Bernard, and David Hill. Elementary Linear Algebra with Applications. 9th Edition., Pearson, 2014.
4. Strang, Gilbert, and Betsy Coonley. Linear Algebra and Its Applications. 4th Edition.,

Brooks/Cole, 2005
5. Anton, Howard, Irl Bivens, and Chris Davis. Elementary Linear Algebra: Applications Version. 12th Edition., Wiley, 2020.

Course Name:	**Technical and Business Writing**
Course Code:	
Course Area:	Mathematics & Supporting Courses
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Functional English

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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Organizing information and generating solution	C	2 (Understand)
CLO 2	Designing document with best layout and structure	C	3 (Apply)
CLO 3	creating the professional report	C	6 (Create)

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, Articles, Research Papers, Feasibility Reports, Project Reports, Technical Research Reports, Manuals and Documentation, Thesis. Electronic Documents, Writing Hypotheses, Questions and Evidence, Describing Mathematics, Describing Algorithms, Explaining Graphs, Figures, and

Tables, Discussing Experimentation, Writing a Paper, Presentations, Introduction to Latex, Introduction to Popular Reference Management Tools such as EndNote, Mendeley.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Zobel, Justin. Writing for Computer Science. 3rd Edition., Springer London, 2014.
2. Hardesty, Ray E. Technical and Business Writing for Working Professionals. Xlibris, 2011.
3. Brown, Bill Wesley. Successful Technical Writing: Documentation for Business and Industry. 2nd Edition., Goodheart-Willcox, 2000.

3.5 AI Elective Supporting Courses

This AI Elective Supporting area consists of 1 course, comprising 3 credit hours, as outlined below:

Course Name:	**Computation in MATLAB**
Course Code:	MATH-432
Course Area:	Elective Supporting Courses
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction

This course familiarizes students with the implementation of mathematical concepts in MATLAB.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand basic concepts, principles and methods of MATLAB programming	C	2 (Understand)
CLO-2	Write small programs for mathematical problems and to perform computations in MATLAB.	C	3 (Apply)
CLO-3	Use MATLAB effectively.	C	3 (Apply)

Course Outline

Introduction to MATLAB Windows, Built-in Functions, Arrays, Matrices, Script Files, Plots, Functions and Function Files, Loops, Selection Statements, Polynomials, Curve Fitting and Interpolation.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Lipsman, Ronald L., et al. A Guide to MATLAB: For Beginners and Experienced Users. 3rd Edition., Cambridge University Press, 2014.
2. Etter, Delores M., David C. Kuncicky, and Douglas W. Hull. Introduction to MATLAB. 4th Edition., Pearson, 2018.
3. Moore, Holly. MATLAB for Engineers. 4th Edition., Pearson, 2022.

3.6 General Education Requirement Courses as per HEC UG Education Policy

This AI General Education area consists of 12 course, comprising 30 credit hours, as outlined below:

Course Name:	**Application of Information and Communication Technologies**
Course Code:	CS101
Course Area:	General Education
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction

Main objective of the course is to build an appreciation for the fundamental concepts in computing and to become familiar with PC productivity software.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand basics of computing technology (software hardware and computer networks)	C	2 (Understand)
CLO-2	Understand number systems conversions and arithmetic	C	2 (Understand)
CLO-3	Have knowledge of types of software and computing related technologies	C	2 (Understand)
CLO-4	Apply knowledge of software and computing related technologies	C	3 (Apply)

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 Computer, Introduction to CBIS (Computer Based Information System), Methods of Input and Processing, Class2. Organizing Computer Facility, Centralized Computing Facility, Distributed Computing Facility, Decentralized Computing Facility, 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, Common Services available on Internet, Introduction to MS Word, MS Excel, MS PowerPoint.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Shelly, Gary B., and Misty E. Vermaat. Discovering Computers: Digital Technology, Data, and Devices. 17th Edition., Cengage Learning, 2022.
2. Sinha, P.K. Computer Fundamentals. 8th Edition., BPB Publications, 2020.
3. Williams, Brian K. Using Information Technology: A Practical Introduction to Computers & Communications. 11th Edition., McGraw-Hill Education, 2015.
4. O'Leary, Timothy J., and Linda I. O'Leary. Computing Essentials 2024. 29th Edition., McGraw-Hill Education, 2023.

Course Name:	**Functional English**
Course Code:	
Course Area:	General Education
Credit Hours:	3 (3-0)
Contact Hours:	3-0
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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Essay Writing and Sentence Errors	C	1 (Remember)
CLO 2	Deliver Oral Presentations	C	3 (Apply)
CLO 3	Narration and Reviewing	C	5 (Evaluate)

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 Material

The following is the recommended list of books (or their latest editions):

1. Langan, John. College writing skills with readings. 5th Edition. New York (2001).
2. Khattak, Arif. A Textbook of English Prose and Structure. GIKI Institute, 2000.
3. Bloor, Thomas, and Meriel Bloor. The functional analysis of English: A Hallidayan approach. 3rd Edition. Routledge, 2013.
4. Klammer, Thomas P. Analyzing English Grammar, 4th Edition. Pearson Education India, 2004.

Course Name:	**Expository Writing**
Course Code:	
Course Area:	General Education
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction

The course introduces students to communications so they can effectively communicate their message. The course also covers how to make an effective presentation, both written and verbal. Various modern techniques of communication and presentation skills are covered in this course. Further the course aims to enhance students' linguistic command, so they could communicate effectively in diversified socio-cultural situations; create larger stretches of interactive text in speech and writing; and identify and repair any instances of potential communication break-up.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Principles of writing good English, understanding the composition process	C	1 (Remember)
CLO 2	Process of writing, observing, audience collecting, composing, drafting and revising	C	2 (Understand)
CLO 3	Presentation skills and presentation strategies,	C	3 (Apply)

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.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Vawdrey, Colleen, Ted D. Stoddard, and R. DerMont Bell. Practical Business English. Richard d Irwin,1993.
2. Nielsen, John. Effective Communication Skills: The Foundations for Change. Xlibris Corporation, 2008.
3. Langan, John. College writing skills with readings. 5th Edition. McGraw-Hill Education. 2001.
4. Khattak, Arif. A Textbook of English Prose and Structure. GIKI Institute, 2000.

Course Name:	**Discrete Structures**
Course Code:	CS120
Course Area:	General Education
Credit Hours:	3 (3-0)
Contact Hours:	3-0
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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.	C	2 (Understand)
CLO-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	C	3 (Apply)

CLO-3	Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C	3 (Apply)
CLO-4	Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular	C	4 (Analyze)

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, mappings, 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 Material

The following is the recommended list of books (or their latest editions):

1. Rosen, Kenneth H. Discrete Mathematics and Its Applications. 7th Edition., McGraw-Hill Education, 2012.
2. Epp, Susanna S. Discrete Mathematics with Applications. 4th Edition., Cengage Learning, 2010.
3. Johnsonbaugh, Richard. Discrete Mathematics. 7th Edition., Pearson, 2018.
4. Kolman, Bernard, Robert Busby, and Sharon Ross. Discrete Mathematical Structures. 4th Edition., Pearson, 2014.
5. Grimaldi, Ralph P. Discrete and Combinatorial Mathematics: An Applied Introduction. Pearson, 2016.
6. Grassmann, Winifred. Logic and Discrete Mathematics: A Computer Science Perspective. Springer, 2007.

Course Name:	**Calculus and Analytical Geometry**
Course Code:	
Course Area:	General Education
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction

The course focuses on differential and integral calculus and other topics that are relevant to undergraduate program studies.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Techniques of funding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications	C	1 (Remember)
CLO 2	Differentiation, Geometrical and Physical meaning of derivatives	C	2 (Understand)
CLO 3	Concept and idea of Integration	C	2 (Understand)
CLO 4	Applications of Integration; Area under the curve, Analytical Geometry	C	3 (Apply)

Course Outline

Real Numbers and the Real Line, Coordinates, Lines, and Increments, Functions, Shifting Graphs, Trigonometric Functions. Limits and Continuity: Rates of Change and Limits, Rules for Finding Limits, Target Values and Formal Definitions of Limits, Extensions of the Limit Concept, Continuity, Tangent Lines. Derivatives: The Derivative of a Function, Differentiation Rules, Rates of Change, Derivatives of Trigonometric Functions, The Chain Rule, Implicit Differentiation and Rational Exponents, Applications of Derivatives. Integration: Indefinite Integrals, Integration by Substitution, Definite Integrals, Substitution in Definite Integrals, Numerical Integration, Applications of Integrals, Transcendental Functions: Inverse Functions and Their Derivatives, Natural Logarithms, The Exponential Function, ax and logax, Growth and Decay, L'Hôpital's Rule, Relative Rates of Growth, Inverse Trigonomic Functions, Derivatives of Inverse Trigonometric Functions; Hyperbolic Functions. Conic Sections, Parameterized Curves, and Polar Coordinates, Graphing in Polar Coordinates, Polar, Equations for Conic Sections, Integration in Polar Coordinates. Vectors and Analytic Geometry in Space, Vectors in the Plane Dot Products, Vector-Valued Function Cartesian (Rectangular) Coordinates and Vectors in Space, Dot Products, Cross Products, Lines and Planes in Space Cylinders and Quadric Surfaces, Cylindrical and Spherical Coordinates.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Thomas, G. B. & Finney, R. L. (1995). Calculus and Analytic, 10th Edition. Addison Wesley.
2. Swokowski, E. W. (1194). Calculus and Analytical Geometry, 6th Edition. rooks/Cole Publishers.
3. Anton, H., Bivens, I., & Davis, S. (2012). Calculus, 10th Edition. Hoboken: Wiley.
4. Anton, H., Bivens, I. C.,
5. & Davis, C. (2012). Calculus, 10th Edition. Wiley.

6. Anton, H. (1995). Calculus with Analytic Geometry: Student Solution Manual, 5th Edition. Willy.

Course Name:	**Islamic Studies**
Course Code:	
Course Area:	General Education
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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	To further enhance the knowledge of Islam	C	1 (Remember)
CLO-2	To understand the basic concept of Islam and Quran Pak	C	2 (Understand)
CLO-3	To understand the concept of Haqooq ul ibad in the light of Quran	C	2 (Understand)
CLO-4	To know the importance of Islamic concept about other religions	C	4 (Analyze)

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 Material

The following is the recommended list of books (or their latest editions):

1. Hamidullah, Dr. Introduction to Islam. Popular Library Publishers, Lahore.
2. Hassan, Ahmad. Principles of Islamic Jurisprudence. Islamic Research Institute, International Islamic University Islamabad.
3. Waliullah, Mir. Muslim Jurisprudence and the Quranic Law of Crimes. Islamic Books Services.

Course Name:	Ideology and Constitution of Pakistan
Course Code:	
Course Area:	General Education
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.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	To further educate students about the history of Pakistan	C	1 (Remember)
CLO-2	To educate student about the various pillar of the state	C	2 (Understand)
CLO-3	To educate student Government and politics	C	2 (Understand)

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 Material

The following is the recommended list of books (or their latest editions):

1. Chaudhury, M. The Emergence of Pakistan. 1967.
2. Aziz, K. The Making of Pakistan. 1976.
3. Qureshi, I. H., editor. A Short History of Pakistan. Karachi, 1988.
4. Rabbani, M. Ikram. A Comprehensive Book of Pakistan Studies. 3rd Edition., The Caravan Press, 2001.

Course Name:	Entrepreneurship
Course Code:	
Course Area:	General Education

Credit Hours: 3 (3-0)
Contact Hours: 3-0
Pre-requisites: None

Course Introduction

This course is designed to help students evaluate the business skills and commitment necessary to successfully operate an entrepreneurial venture and review the challenges and rewards of entrepreneurship. Students will learn about themselves, their decisions, and their goals to determine how entrepreneurship can play a role in their lives. Students will also be introduced to entrepreneurship from an economic perspective and the concepts of environmentally sustainable practices and social entrepreneurship.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Identify and assess sources of support for small businesses and entrepreneurs	C	2 (Understand)
CLO-2	Identify the critical factors that are used to identify business start-up ideas – including forms of ownership	C	2 (Understand)
CLO-3	Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture. Identify the critical concepts of business planning and increase chances of business success	C	2 (Understand)
CLO-4	Discuss examples of current entrepreneurs.	C	4 (Analyze)

Course Outline

Entrepreneurship and the Entrepreneurial Mind-Set. Entrepreneurial Intentions and Corporate Entrepreneurship. Entrepreneurial Strategy. Generating and Exploiting New Entries. Creativity and the Business Idea. Identifying and Analyzing Domestic and International Opportunities. Intellectual Property and Other Legal Issues for the Entrepreneur. The Business Plan. Creating and Starting the Venture. The Marketing Plan. The Organizational Plan. The Financial Plan. Sources of Capital. Informal Risk.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Hisrich, Robert D., Michael P. Peters, and Dean A. Shepherd. Entrepreneurship. 9th Edition., McGraw-Hill/Irwin, 2012.
2. Greene, Christopher L. Entrepreneurship: Ideas in Action. 5th Edition., South-Western Educational Pub, 2011.
3. Bygrave, William D., and Andrew Zacharakis. Entrepreneurship. 2nd Edition., Wiley, 2010.
4. Kuratko, Donald F. Entrepreneurship: Theory, Process, and Practice. 8th Edition., South-Western College Pub, 2008.

5. Barringer, Bruce R., and R. Duane Ireland. Entrepreneurship: Successfully Launching New Ventures. 4th Edition., Prentice Hall, 2011.

Course Name:	**Civics and Community Engagement**
Course Code:	
Course Area:	General Education
Credit Hours:	2 (2-0)
Contact Hours:	2-0
Pre-requisites:	None

Course Introduction

This course is designed to provide students with fundamental knowledge about civics, citizenship, and community engagement. In this course, the students will learn about the essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Demonstrate fundamental understanding of civics, government, citizenship and civil society.	C	2(Understand)
CLO-2	Understand the concept of community and recognize the significance of community engagement for individuals and groups.	C	2(Understand)
CLO-3	Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.	C	4(Analyze)

Course Outline

1. Civics and Citizenship
- Concepts of civics, citizenship, and civic engagement.
- Foundations of modern society and citizenship.
- Types of citizenship: active, participatory, digital, etc.

2. State, Government and Civil Society
- Structure and functions of government in Pakistan.
- The relationship between democracy and civil society.
- Right to vote and importance of political participation and representation.

3. Rights and Responsibilities
- Overview of fundamental rights and liberties of citizens under Constitution of Pakistan 1973.
- Civic responsibilities and duties.
- Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.)

4. Community Engagement
- Concept, nature and characteristics of community.
- Community development and social cohesion.
- Approaches to effective community engagement.
- Case studies of successful community driven initiatives.

5. Advocacy and Activism

- Public discourse and public opinion.
- Role of advocacy in addressing social issues.
- Social action movements.

6. Digital Citizenship and Technology

- The use of digital platforms for civic engagement.
- Cyber ethics and responsible use of social media.
- Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship.

7. Diversity, Inclusion and Social Justice

- Understanding diversity in society (ethnic, cultural, economic, political etc.).
- Youth, women and minorities' engagement in social development.
- Addressing social inequalities and injustices in Pakistan.
- Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

As part of the overall learning requirements, the course may have one or a combination of the following practical activities:

1. Community Storytelling: Students can collect and share stories from community members. This could be done through oral histories, interviews, or multimedia presentations that capture the lived experiences and perspectives of diverse individuals.
2. Community Event Planning: Students can organize a community event or workshop that addresses a specific issue or fosters community interaction. This could be a health fair, environmental cleanup, cultural festival, or educational workshop.
3. Service-Learning: Students can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time and skills to address a particular community need, such as tutoring, mentoring, or supporting vulnerable populations.
4. Cultural Exchange Activities: Students can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances, and presentations that promote cross-cultural understanding.

Reference Material

The following is the recommended list of books (or their latest editions):

1. Remy, R. C. (2005). Civics Today: Citizenship, Economics, & You. United States: Glencoe/McGraw-Hill.
2. Kymlicka, W. (2000). Citizenship in diverse societies. Oxford University Press.
3. Youniss, J., & Levine, P. (2009). Engaging Young People in Civic Life: Vanderbilt University Press.
4. Mattson, K. (2024). Digital citizenship in action: empowering students to engage in online communities. International Society for Technology in Education.
5. Kronick, R. F. (2018). Community Engagement: Principles, Strategies and Practices. United States: Nova Science Publishers, Incorporated.

3.7 Arts & Humanities Course

Course Name:	Professional Practices
Course Code:	CS423
Course Area:	General Education
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, assess ethical & professional computing case studies.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Bloom's Taxonomy Level
CLO-1	Understand the concepts of key, ethical, managerial and legal issues typically encountered by an IT professional.	C	2(Understand)
CLO-2	Identify, access and critically review appropriate and relevant literature drawn from academic, technical, legal, professional business sources.	C	3(Apply)
CLO-3	Evaluate and critically reflect upon self-presentation.	C	5(Evaluate)

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 Material

The following is the recommended list of books (or their latest editions):

1. Bott, Frank, Allison Coleman, Jack Eaton, and Diane Rowland. Professional Issues in Software Engineering. 3rd Edition., CRC Press, 2000.
2. Johnson, Deborah G. Computer Ethics. 4th Edition., Pearson, 2009.
3. Bott, Frank. Professional Issues in Information Technology. 2nd Edition., BCS Learning & Development Limited, 2014.
4. Baase, Sara. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet. 3rd Edition., Prentice Hall, 2008.
5. Beabout, Gregory R. Applied Professional Ethics. University Press of America, 1993.

3.8 Natural Sciences Course

Course Name:	**Applied Physics**
Course Code:	
Course Area:	General Education
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction

The course introduces students with the 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 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.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO 1	Apply the principles of electric force, fields, and laws to analyze and solve problems	C	3 (Apply)
CLO 2	Understand and calculate electric potential energy and electric potentials for different charge distributions	C	2 (Understand)
CLO 3	Analyze and solve problems involving electric current, resistance, and magnetic forces using different laws including applications in electromagnetism and wave optics.	C	4 (Analyze)

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 Material

The following is the recommended list of books (or their latest editions):

1. Halliday, David, Robert Resnick, and Jearl Walker. Fundamentals of physics. John Wiley & Sons, 2013.
2. Garcia, Narciso, and Arthur Damask. Physics for computer science students: with emphasis on atomic and semiconductor physics. Springer Science & Business Media, 2012.