Annexure-D

Curriculum for
BS Software Engineering

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF PESHAWAR
SESSION 2024

1. BS Software Engineering

Software Engineering (SE) is the discipline of developing and maintaining software systems that behave reliably and efficiently. It differs from general programming which is just the skill to program. Whereas Software Engineering refers to the whole process of teamwork and continual development of a software project which has a life span and is developed in versions.

A bachelor's degree in Software Engineering can be vital for several reasons, especially in today's technology-driven world. It provides a solid grounding in the principles of software development, including algorithms, data structures, software architecture, and design patterns. Software Engineering program emphasizes problem-solving and critical thinking. Graduates are trained to approach complex problems methodically and develop innovative solutions. The curriculum covers the latest technologies and methodologies used in the industry, such as Agile development, DevOps, and AI driven development. It also includes hands-on projects and collaborative work that provide practical experience. This experience is invaluable for understanding real-world challenges and for building a professional portfolio. A degree in Software Engineering opens doors to various career paths, including software development, system analysis, quality assurance, and project management. The skills gained are applicable in many sectors, from tech companies to finance, healthcare, and beyond. Software Engineering is known for offering competitive salaries and opportunities for advancement. The technical expertise and problem-solving abilities of software engineers are highly valued, often leading to lucrative job prospects. The field of Software Engineering is constantly evolving with new technologies and methodologies. A strong educational background helps professionals adapt and continue learning throughout their careers. Overall, a BS in Software Engineering equips individuals with the skills and knowledge needed to tackle complex software challenges, contribute effectively to teams, and succeed in a variety of tech-driven careers.

Imparting all necessary skill set required by the industry to future software graduates is quite a challenge for learning in an academic setting. To deal with this a Software Engineering curriculum must focus on concepts needed by most new-graduate hires. This skillset, identified by ACM in Computer Science Curricula 2023 report[1], includes compulsory training in software testing, teamwork, collaboration, communication, software design, maintenance and evolution, and Software engineering tools. This program offered by the department is designed keeping in view this skill set by following the guidelines of HEC-NCEAC[2] and HEC Undergraduate Policy[3] where applicable.

1.1 Program Educational Objectives

Teaching Software development practices requires more than just the underlying principles of Computer Science. Software Engineering embodies techniques within systematic and organized processes and offers the rigor that the engineering disciplines bring to the reliability and trustworthiness of the artifacts. Still Software Engineering is different in character from other engineering disciplines, due to both the intangible nature of software and to the discontinuous nature of software operation. It seeks to integrate the science of

[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

Computer Science with the engineering principles developed for tangible and physical phenomena.

The Department of Computer Science aims to prospective Software Engineers students in all aspects of software development life cycle along with all the necessary organizational, collaboration, and professional skills necessary for their productive participation in the professional software development. Following are the Program Educational Objectives' (PEOs) set for BS in Software Engineering program of the department.

The graduates from the Software Engineering program shall demonstrate the following characteristics upon graduation

PEO (1): Professional Practice. Graduates will be able to apply the principles of Software Engineering to develop solutions for complex software development problems, pertinent either to industry or academia.

PEO (2): Leadership and Teamwork. Software Engineering skills will also enable graduates to demonstrate leadership skills, effective communication, and the ability to work collaboratively in multidisciplinary teams.

PEO (3): Ethics and Societal Implications. Graduates will be able to demonstrate an understanding of professional, ethical, legal, security, and social issues and responsibilities that underpin good software engineering practice.

PEO (4): Continuous Learning for Career Advancement. Graduates will be able to engage themselves in lifelong learning activities, either in the form of self-study, professional development activities, or further education in the field of software engineering or other related fields. This will allow graduates to advance in their careers, accepting increasing levels of responsibility and contributing effectively towards the success of their various organizations.

1.2 Program Learning Outcomes

Program Learning Objectives (PLOs) describe what students are expected to know and can do by the time of graduation considering the knowledge, skills and attitude they acquire while progressing through the program. The BS Software Engineering graduates of the Department of Computer Science, University of Peshawar demonstrate the following graduate attributes (PLOs) in their professional careers.

S#	Program Learning Outcome	Computing Professional Graduate
1	Academic Education	To prepare graduates as computing professionals.
2	Knowledge for Solving Computing Problems	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements.
3	Problem Analysis	Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.
4	Design/Development of Solutions	Design and evaluate solutions for complex computing problems, and design and evaluate systems, components,

		or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
5	Modern Tool Usage	Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations.
6	Individual and Teamwork	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.
7	Communication	Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions.
8	Computing Professionalism and Society	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice.
9	Ethics	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.
10	Life-long Learning	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional,

1.3 Mapping of PEOs and PLOs

BS Software Engineering					
S#	**PLOs**	**Program Educational Objectives**			
		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 Scheme of Studies for BS Software Engineering Program

2.1 Structure for BS Software Engineering

The following table shows the generic structure provided by HEC for BS SE program.

Areas	**Credit Hours**	**Courses**
Computing Core	46	14
Domain Core	18	06
Domain Electives	21	07
Mathematics & Supporting Courses	12	04
Elective Supporting Courses	03	01
General Education	33	12
Total	**133**	**44**

2.2 Area Wise Curriculum Split for BS SE Program

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

#	Semester #	Course Code	Pre-Requisite	Course Title	Domain	Credit Hours
Computing Core (46/133) 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	2	CS121	-	Computer Networks	Computing Core	3(2-3)
5	3	CS206	-	Database Systems	Computing Core	4(3-3)
6	3	CS202	CS123	Data Structures	Computing Core	4(3-3)
7	3	CS204	-	Software Engineering	Computing Core	3(3-0)
8	3	CS201	CS123	Artificial Intelligence	Computing Core	3(2-3)
9	4	CS203	-	Information Security	Computing Core	3(2-3)
10	4	CS208	CS202	Operating Systems	Computing Core	3(2-3)
11	4	CS205	CS202	Analysis of	Computing Core	3(3-0)

				Algorithms		
12	4	CS207	CS122	Computer Organization and Assembly Language	Computing Core	3(2-3)
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)
SE Domain Core (18/133) 6 Courses						
15	5	CS309	CS204	Software Design and Architecture	SE Core	3(3-0)
16	5	CS310	CS204	Software Requirement Engineering	SE Core	3(2-3)
17	6	CS312	CS102, CS204	Software Quality Engineering	SE Core	3(2-3)
18	6	CS334	CS309	Software Construction and Development	SE Core	3(2-3)
19	7	CS335	CS204	Software Project Management	SE Core	3(3-0)
20	8	CS403	CS123, CS208	Parallel & Distributed Computing	SE Core	3(2-3)
SE Domain Elective (21/133) 7 Courses						
21	5-8	CS325	CS102, CS204	Software Testing and Quality Assurance	SE Elective	3(2-3)
22	5-8	CS324	CS123, CS 204	Object Oriented Analysis and Design	SE Elective	3(2-3)
23	5-8	CS327	CS207	Computer Architecture	SE Elective	3(2-3)
24	5-8	CS311	CS202, CS102	Theory of Automata	SE Elective	3(3-0)
25	5-8	CS319		Human Computer Interaction	SE Elective	3(2-3)
26	5-8	CS323	CS123	Web Technologies	SE Elective	3(2-3)
27	5-8	CS301	CS206	Advanced Database Management Systems	SE Elective	3(2-3)
	5-8	CS349	CS123	Web Engineering	SE Elective	3(2-3)
	5-8	CS318	CS201, Probability and Statistics	Data Mining	SE Elective	3(2-3)
	5-8	CS409	CS309	Software Re-	SE Elective	3(2-3)

				Engineering		
	5-8	CS341	CS123	Mobile Application Development	SE Elective	3(2-3)
	5-8	CS412	CS204	Software Engineering Economics	SE Elective	3(3-0)
	5-8	CS303	CS203	Cyber Security	SE Elective	3(2-3)
	5-8	CS405	CS201, CS204	Artificial Intelligence for Software Engineering	SE Elective	3(2-3)
	5-8	CS344	CS334	Software Process Improvement	SE Elective	3(3-0)
	5-8	CS414	CS204	Sustainability Aspects in Software Engineering	SE Elective	3(2-3)
	5-8	CS348	-	User Experience Design	SE Elective	3(2-3)
	5-8	CS406	-	Business Process Analysis	SE Elective	3(2-3)
	5-8	CS339	CS204	Technology Trends in Software Engineering	SE Elective	3(2-3)
	5-8	CS314	CS123	Advanced Programming	SE Elective	3(2-3)
Mathematics and Supporting (12/133) 4 Courses						
28	1			Probability & Statistics	Mathematics and Supporting	3(3-0)
29	4			Multivariate Calculus	Mathematics and Supporting	3(3-0)
30	5			Applied Linear Algebra	Mathematics and Supporting	3(3-0)
31	7			Technical and Business Writing	Mathematics and Supporting	3(3-0)
Elective Supporting (3/133) 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 (HEC UG Education Policy) - 12 Courses (33/133)						

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)
	1		-	Religious Education/Ethics	General Education	2(2-0)
39	1		-	Ideology and Constitution of Pakistan	General Education	2(2-0)
40	4		-	Natural Sciences	General Education	3(2-3)
41	7		-	Social Sciences	General Education	3(3-0)
42	7	BA565	-	Entrepreneurship	General Education	3(3-0)
43	8		-	Arts & Humanities (Professional Practices)	General Education	3(3-0)
44	8		-	Civics and Community Engagement	General Education	2(2-0)

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 arts and humanities.				

Natural Sciences Course Pool

#	Course Code	Course Title	Credit Hours	Department
1		Applied Physics	3(2-3)	
Any other University of Peshawar approved course from natural sciences.				

2.3 Semester Plan for BS SE

#	Code	Course Title	Domain	Cr Hr
Semester 1				
1	CS102	Programming Fundamentals	Computing Core	4(3-3)
2		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	MATH-432	Computation in MATLAB	Elective Supporting	3(2-3)
28		Applied Linear Algebra	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**18(14-12)**
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 Elective	General Education	3(3-0)
			Total Cr. Hrs	**16(12 - 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 Elective (Professional Practices)	General Education	3(3-0)
44		Civics and Community Engagement	General Education	2(2-0)
			Total Cr. Hrs	**15(05-18)**

* 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 outlines for BS Software Engineering

This section provides detailed course outline for all courses from all areas of BS Software Engineering including the course title, course code, credit hours split, pre-requisite, course introduction, course learning outcomes, and reference materials.

3.1 BS SE Computing Core Courses

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 courses 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. Dietel, Paul, and Harvey, Dietel. C++ How to Program. Prentice Hall, 2019.
2. Lafore, Robert. Object-Oriented Programming in C. Indianapolis, Sams, 2005.
3. Sahay, Sourav. Object Oriented Programming with C. Oxford University Press, 2012.
4. Kanetkar, Yashavant. Basic Programming in C++. 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	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	3(Apply)
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(Analyze)

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 Deitel, Harvey. C++ How to Program. Prentice Hall, 2016.
2. Laurence, Paul. C++ The Ultimate Crash Course to Learning the Basics of C++. CreateSpace Independent Publishing Platform, 2017.
3. Lafore, Robert. Object-Oriented Programming in C. Indianapolis, Ind Sams, 2005.
4. Kanetkar, Yashavant. Basic Programming in C++. BPB Publications, 2004.

Course Name	**Digital Logic Design**
Course Code	CS122

Course Area	Computing Core
Credit Hours	3 (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 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) & C 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, Mano. Digital Logic and Computer Design, 6th edition. Pearson Education India, 2009.
2. Floyd, Thomas. Digital Computer Electronics, 11th edition. Pearson Education India, 2014.
3. Mazumder, Pinaki, and Idongesit E. Ebong. Lectures on Digital Design Principles. River Publishers, 2023.

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

Course Introduction

The purpose of this course is to provide the students with solid foundations in the basic concepts of programming data structures and algorithms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy Domain**	**Level**
CLO-1	Understand various data structures and their algorithms and apply them in implementing simple applications	C	2 (Understand)& 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. Drozdek, Adam. Data Structures and Algorithms in C++, 4th Edition, Cengage Learning, 2012
2. Weiss, Mark. Data Structures and Algorithm Analysis in C++. 4th Edition. Pearson, 2013.
3. Miller, Bradley. et al. Problem Solving with Algorithms and Data Structures Using Python, 3rd Edition. Franklin, Beedle & Associates, 2023.
4. Lambert, Kenneth. Fundamentals of Python Data Structures. 2nd Edition. Cengage Learning, 2018.
5. Weiss, Mark. Data Structures and Algorithm Analysis in Java. 3rd edition. Pearson, 2011.

Course Name	**Database Systems**
Course Code	CS206
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 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. Database Systems A Practical Approach to Design, Implementation, and Management. 6th Edition. Pearson India, 2019.
2. Garcia-Molina, Hector. Database Systems The Complete Book. 2nd Edition. Pearson, 2008.
3. Sudarshan, S, et al.. Database System Concepts, 7th Edition. Generic, 2021.
4. Ramakrishnan, Raghu, and Gehrke, Johannes. Database Management Systems, 3rd Edition. Mc Graw Hill India, 2014.

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 Outcome**	**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	**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. Norvig, Peter, and Russell, Stuart. Artificial Intelligence A Modern Approach, 4th Edition. Pearson, 2022.
2. Artsanchez, Alberto, and Joshi, Prateek. Artificial Intelligence with Python. 2nd Edition. Packt Publishing, 2020.
3. Miller, Bradley, and Ranum, David; Anderson, Julie. Python Programming in Context. 3rd Edition. Jones & Bartlett Learning, 2019

Course Name	**Computer Networks**
Course Code	CS121
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, Willaim. Data and Computer Communications. 10th Edition. Pearson, 2013
2. Forouzan, Behrouz. Data Communications and Networking, 5th Edition. McGraw Hill, 2012.
3. Tenanbaum, Andrew, and Wetherall, David. Computer Networks, 6th Edition. Pearson, 2021.
4. Kuros, James, and Ross, Keith. Computer Networks A Top-down Approach. 7th Edition. Pearson, 2016

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	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. Silberschatz, Abraham; Galvin, Peter; Gagne, Greg. Operating System Concepts, 10th Edition. John Wiley & Sons, 2021.
2. Tanenbaum, Andrew; Hebert, Bos. Modern Operating Systems, 5th Edition. Pearson, 2022.

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	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, et al. Introduction to Algorithms. 4th Edition. The MIT Press, 2022
2. Kleinberg, Jon, and Tardos, Eva. Algorithm Design. Pearson, 2005.

3. Sedgewick, Robert, and Wayne, Kevin. Algorithms. 4th Edition. Addison-Wesley Professional, 2011.

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. 6th Edition. Morgan Kaufmann, 2020.
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	**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	**Final Year Project – I**
Course Code	CS401
Course Area	Computing Core
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	None

Course Introduction

CLO No.	**Course Learning Outcome**	**Bloom's Taxonomy Domain**	**Level**
CLO-1	Analysis and Design of FYP	C	6 (Create)

Course Outline

Analysis and Design of FYP

Reference Material

Course Name	**Final Year Project – II**
Course Code	CS402
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	**Final Year Project – I**

Course Introduction

CLO No.	Course Learning Outcome	Bloom's Taxonomy Domain	Level
CLO-1	Thesis and complete FYP submission	C	6 (Create)

Course Outline

Thesis and complete FYP submission

Reference Material

3.2 Software Engineering Domain Core

This Software Engineering **Domain Core** area consists of 6 courses, comprising 18 credit hours, as outlined below

Course Name	**Software Requirements Engineering**
Course Code	CS312
Course Area	Domain Core
Credit Hours	3 (3-0)
Contact Hours	
Pre-requisites	**Software Engineering**

Course Introduction

CLO No.	Course Learning Outcome	Bloom's Taxonomy Domain	Level
CLO-1	Describe the requirements engineering process	C	2 (Understand)
CLO-2	Effectively analyze software requirements for the development of cost-effective and efficient technical solutions.	C	4 (Analyze)
CLO-3	Prepare both functional and non-functional requirements along with validation for a medium-size software system.	C	6 (Create)
CLO-4	Document effective requirements in Software Requirements Specification (SRS) using clear, unambiguous requirements.	C	6 (Create)

Course Outline

Introduction to Requirements Engineering, Software Requirements, classification of requirements, Levels/layers of requirements, Understanding Functional/Non-Functional, usability and sustainability requirements, Requirement characteristics, Analyzing quality requirements, Software requirements in the context of systems engineering, RE evolutionary process, RE basic process, RE in software lifecycle, Process vs. product specifications, Requirement elicitation, elicitation sources and techniques, Requirements modeling, Use case modeling, Requirement specification and documentation, specification sources and techniques, Requirements validation and techniques, Management of Requirements, Requirement traceability, requirement prioritization, trade-off analysis, risk analysis and impact analysis, Interaction between requirement and architecture, Architectural requirements, Managing

Requirements in an Acquisition Organization, Supplier Organizations, Product Organizations, Requirements engineering for agile methods. Modern trends in requirement engineering

Reference Material

1. Wiegers, Karl E., and Joy Beatty. Software Requirements. Pearson Education, 2013
2. Hull, Elizabeth, et al. Requirements Engineering. Springer Science and Business Media, 3rd ed. 2013
3. Requirements Engineering and Management for Software Development Projects. Springer Science and Business Media, 2012,
4. Amuthabala, K., et al. *Agile Software Development - An Overview*. MileStone Research Publications, 2023
5. Heath, Fred. *Managing Software Requirements the Agile Way*. Packt Publishing Ltd, 2020,

Course Name	**Software Design and Architecture**
Course Code	CS309
Course Area	Domain Core
Credit Hours	3 (2-3)
Contact Hours	
Pre-requisites	**Software Engineering**

Course Introduction

Software architecture and design introduces several contributory factors such as Business strategy, quality attributes, human dynamics, design, and IT environment.

CLO No.	**Course Learning Outcome**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-2	Comprehend the advantages of consistent and reliable software design.	C	2(Understand)
CLO-3	Design OOD models and refine them to reflect implementation details	C	3(Apply)
CLO-4	Apply and use UML to visualize and document the design of software systems.	C	3(Apply)

Course Outline

Architectural design issues Software Architecture, Architectural Structures & Styles, Architectural Patterns, Architectural & Design Qualities, Quality Tactics, Architecture documentation, Architectural Evaluation. Software Design Concepts, Design principles, Object-Oriented Design with UML, Object design, System design and software architecture, Mapping design to code, User interface design, Persistent layer design, Web

applications design, Design Patterns, Exploring inheritance, Interactive systems with MVC architecture, Software reuse. Model driven development, State machine diagrams and modeling.

Reference Material

1. Pressman, Roger S., and Bruce R. Maxim. *Software Engineering*. McGraw Hill, 2019
2. Object-Oriented Analysis, Design and Implementation, Brahma Dathan, Sarnath Ramnath, 2nd Ed, Universities Press, India, 2014.
3. Richards, Mark, and Neal Ford. *Fundamentals of Software Architecture*. O'Reilly Media, 2020
4. Head First Design Patterns, Eric Freeman, Elisabeth Freeman, Kathy Sierra and Bert Bates, O'Reilly Media, Inc. 2004.

Course Name	**Software Construction and Development**
Course Code	CS334
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	
Pre-requisites	**Software Design and Architecture**

Course Introduction

This course is designed to introduce fundamental principles and techniques of software development to develop easy to understand, error free and modifiable systems. To deal with code complexity, changeability, reusability, and to explicitly learn unit development and integration issues.

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

Course Outline

Software development process, Software engineering process infrastructure, Software engineering process improvement, Systems engineering life cycle models, Process implementation, Levels of process definition, Life cycle model characteristics, Individual and team software process, Lehman's Laws, code salvaging, and configuration management. Martin Fowler's refactoring concepts and their application to small projects. Apply Michael Feathers' "legacy code" concepts. Exception handling, making methods robust by having them check their inputs sent from calling objects. Software configuration management, Release management, Software configuration management processes,

Software deployment processes, Distribution and backup, Evolution processes and activities, Basic concepts of evolution and maintenance, Working with legacy systems, Refactoring, Error handling, exception handling, and fault tolerance. Personal reviews (design, code, etc.), Peer reviews (inspections, walkthroughs, etc.).

Reference Material

1. The Robert C. Martin Clean Code Collection. Prentice Hall, 2011
2. Thomas, David, and Andrew Hunt. *The Pragmatic Programmer*. Addison-Wesley Professional, 2019
3. Working Effectively with Legacy Code, Michael C. Feathers. Pearson Education, Prentice-Hall, 2009.
4. Fowler, Martin. *Refactoring*. Addison-Wesley Professional, 2018

Course Name	**Software Project Management**
Course Code	CS335
Course Area	Domain Core
Credit Hours	3 (3-0)
Contact Hours	
Pre-requisites	**Software Engineering**

Course Introduction

This course is aimed to understand the fundamental principles of software project management & have a good knowledge of responsibilities of project manager. It also introduces different methods and techniques used for project management to be able to apply the knowledge in an effective manner.

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

Course Outline

Introduction to Software Project Management, Project Management concepts, Project Management Tools, Understanding Organizations. Project Planning, Project Evaluation,

Selection of an Appropriate Approach in Project, PMI‘s Knowledge areas, PMI Framework, PMI Process Groups. Software Effort Estimation, Activity Planning, Risk Management, Evaluating the Risks to the Schedule, Risk Control, Configuration Management and Maintenance, Environment for Configuration Control, Resource

Allocation, Monitoring & Control, Review and Evaluation, Introduction to other project management philosophies (e.g., Lean, Kanban, Six Sigma, Agile project management), Challenges of Outsourcing in Project Management

Reference Material

1. Radaideh, Moh’d A. Software Project Management. Walter de Gruyter GmbH and Co KG, 2023
2. Stern, Terra Vanzant. Lean and Agile Project Management. CRC Press, 2020
3. Hughes. eBook Software Project Management, 5e. McGraw Hill, 2021
4. Institute, Project Management. A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Seventh Edition, Project Management Institute, 2021,
5. Wysocki, Robert K. Effective Project Management. John Wiley and Sons, 2019

Course Name	**Software Quality Engineering**
Course Code	CS312
Course Area	Domain Core
Credit Hours	3 (3-0)
Contact Hours	
Pre-requisites	Software Engineering, Programming Fundamentals

Course Introduction

CLO No.	**Course Learning Outcome**	**Bloom’s Taxonomy Domain**	**Level**
CLO-1	Differentiate between SQA and SQE.	C	2 (Understand)
CLO-2	Understand SQ models	C	3 (Apply)
CLO-3	Able to understand and apply SQE activities	C	3 (Apply)
CLO-4	Able to understand and apply SQE in SLDC phases	C	3 (Apply)

Course Outline

Software Quality, Introduction, importance and need, Different perspectives and views (internal and external), Causes of software failure; Software Defects, types(errors, faults, failures), cost, CoSQ; Basic model of CoSQ Cost of control (prevention and appraisal costs), Cost of failure of control (internal failure cost, external failure cost)

; Software Quality models (FURPS, McCall, ISO 9126 etc.), quality improvement models (CMMI, Six Sigma etc.); Software Quality Engineering, Process of software

quality engineering; Software quality assurance Definition, importance, relationship of SQA and SQE; QA activities and defect management/handling Defect prevention and associated techniques, Defect detection and removal, and related techniques

Defect containment and related techniques; SQE redefined Activities of quality engineering (pre-QA activities, in-QA activities, post-QA activities), Process of SQE in terms of QA activities; Performing QA activities in SDLC phases Overview of QA activities in different phases; Quality of software requirement engineering QA in requirements gathering, Quality requirements, Requirements defects, Quality in the analysis of requirements, Quality in software design and architecture, QA in software design phase, Quality in software construction and coding, Coding standards, QA in construction phase, Quality in software verification and validation, Quality test cases, Quality review and test processes, Quality and QA activities in software deployment and maintenance, Quality in configuration management, Risk

Reference Material

1. Paul Jorgensen, Software Testing, A Craftsman's Approach, 4th Ed. CRC Press, Taylor and Francis Group, 2015
2. Bernard Homes, Fundamentals of Software Testing, ISTE, Wiley, 2012
3. Sommerville, Ian. Software Engineering. Pearson Higher Ed, 2011
4. Westfall, Linda. The Certified Software Quality Engineer Handbook. Quality Press, 2016

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

Parallel and Distributed Computing is an advanced level programming course that helps to analyze sequential algorithms for possible modifications and implementation on available advance machines. This course will cover the study of various parallel and distributed computing hardware, operating system, algorithm design and implementation techniques in detail.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy Domain**	**Level**
CLO-1	Learn about parallel and distributed computers	C	2 (Understand)

CLO-2	Write portable 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. Van Steen, Maarten, and Andrew S. Tanenbaum. Distributed Systems. Leiden, The Netherlands Maarten van Steen, 2017.
2. Hwang, Kai, J. J. Dongarra, and Geoffrey C. Fox. Distributed and Cloud Computing Clusters, Grids, Clouds, and the Future Internet. Morgan Kaufmann, 2011.
3. Joshi, Unmesh. Patterns of Distributed Systems. Addison Wesley, 2023.

3.3 Software Engineering Domain Elective Course Contents

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

Course Name	**Web Technologies**
Course Code	CS323
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Object Oriented Programming

Course Introduction

This course provides a detailed presentation and understanding of the basic concepts, principles and the essential web development languages, tools, and technologies. Students will experience how to create basic web pages with HTML, including basic structuring of page content, apply basic formatting styles using CSS, understanding JavaScript and client-side scripting, and create dynamic web pages by implementing server-side script to perform operations on a web server.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Understand the fundamentals of web application architecture and web programming technologies	C	2 (Understand)
CLO-2	Apply a structured approach to identifying needs, interests, and functionality of a website to design and develop dynamic websites using HRML, CSS, JavaScript and PHP	C	3 (Apply) & 6 (Create)
CLO-3	Design and implement an interactive website regarding usability, accessibility, and internationalization	C	3 (Apply) & 6(Create)
CLO-4	Analyze and evaluate website with respect to structure, maintainability, accessibility and optimization	C	4 (Analyze) & 5 (Evaluate)

Course Outline

History and Advantages and Disadvantages of Internet, Web Server, Web Browser, Web Clients, and Search Engines, Client-Server Architecture, Types and Categories of Websites, Creation and Basic Structure of HTML Document, HTML Tags (Headings , Paragraphs, Line Break, Horizontal Line, Font, Preformatted Text, Lists, Images, Tables, Hyperlink, Fame, and Form), CSS, Inserting JavaScript Code in HTML Document, JavaScript Constructs (Variables and Rules of Naming Variables, Operators, Type Casting, Decision Control Structures, Loops, Function, Array, and DOM), Creating PHP File, Overview of Variables and Constants, Output Statement in PHP, Passing Variables Between Pages (URL, Sessions, Cookies, and Forms), Accessing and Using Database in PHP, AJAX, Introduction to Service Oriented Architecture and Web Services, Designing and Implementing Web Services with SOAP and JSON.

Reference Material

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

1. Duckett, Jon. Web design with HTML, CSS, JavaScript and jQuery Set. Wiley Publishing, 2014.
2. Nixon, Robin. Learning PHP, MySQL, JavaScript, and CSS A Step-by-Step Guide to Creating Dynamic Websites. " O' Reilly Media, Inc.", 2012.
3. Lars, Laurence. JavaScript from Beginner to Professional. Packt Publishing Limited, 2021.

Course Name	Software Engineering Economics
Course Code	CS412
Course Area	Domain Electives
Credit Hours	3 (3-0)
Contact Hours	
Pre-requisites	Software Engineering

Course Introduction

Software Engineering Economics is about making decisions related to software engineering in a business context. Success of any software engineering project is partly dependent on effective business management. Software engineering economics provides a way to examine the attributes of software and software processes in a systematic way that relates them to economic measures.

CLO No.	Course Learning Outcome	Bloom's Taxonomy Domain	Level
CLO-1	Overview economic analysis techniques and their applicability to software engineering	C	2 (Understand)
CLO-2	Develop software cost estimation skills using industry standards.	C	6 (Create)
CLO-3	Critically evaluate and discuss the issues in cost estimation of different applications in the real world with course participants and learners.	C	5 (Evaluate)

Course Outline

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

Reference Material

1. Geriner, Pamela T., et al. Software Engineering Economics and Declining Budgets. Springer Science and Business Media, 2012
2. Jones, Capers. Estimating Software Costs Bringing Realism to Estimating. McGraw Hill Professional, 2007Software Cost Estimation and Sizing Methods, Issues, and Guidelines, Shari Lawrence Pfleeger, Rand Publishing, 2005.
3. Veryard, Richard. The Economics of Information Systems and Software. Butterworth-Heinemann, 2014

Course Name	Software Re-Engineering
Course Code	CS409

Course Area	Domain Electives
Credit Hours	3 (3-0)
Contact Hours	
Pre-requisites	Software Design and Architecture

Course Introduction

Software re-engineering provides understanding of reorganizing and modifying existing software systems to improve maintainability. It includes activities like reverse engineering, program restructuring, modularization, and data re-engineering.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Understand the concepts and technique of software Re-engineering.	C	2 (Understand)
CLO-2	Apply reengineering techniques to maintain and modify	C	3 (Apply)
CLO-3	Analyze and understand maintenance related problems associated with object-oriented software systems.	C	5 (Analyze)
CLO-4	Able to perform complex design reengineering and reverse engineering problems.	C	3(Apply)

Course Outline

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

Reference Material

1. Rada, Roy. Re-Engineering Software. Taylor and Francis, 2024 (Text Book)
2. Re-engineering legacy software, David Lorge Parnas, Chris Birchall, Safari Books, Shelter Island, NY, 2016
3. Tripathy, Priyadarshi, and Kshirasagar Naik. Software Evolution and Maintenance. John Wiley and Sons, 2014,
4. Bennett, K.H., and Rajlich, V.T. Software Maintenance and Evolution a Roadmap, The Future of Software Engineering, ACM Press 2000.

Course Name	**Mobile Application Development**
Course Code	CS341
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Object Oriented 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	C	2 (Understand) &4 (Analyze)
CLO-2	Understand mobile applications development for the Android operating system that use basic and advanced phone features	C	2 (Understand)
CLO-3	Design, implement, test, debug and publish smartphone applications	C	3 (Apply)
CLO-4	Create innovative and robust mobile applications that will be valuable addition to their programming portfolio	C	6 (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.

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.	C	2 (Understand)
CLO-3	Perform performance analysis and evaluation.	C	4 (Analyze) & 5(Evaluation)
CLO-4	Apply ALU & control unit implementations, memory hierarchy and multiprocessors.	C	3 (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	**Human Computer Interaction**
Course Code	CS319
Course Area	Domain Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	

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 and the process of designing interactive systems.	C	2(Understand)
CLO-3	Awareness and application of design principles for improved user experience.	C	3(Apply)
CLO-4	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. Human-Computer Interaction. Pearson Education, 2004.
2. Rogers, Yvonne, et al. Interaction Design Beyond Human-Computer Interaction. 6th ed., John Wiley & Sons, 6 Mar. 2023.

Course Name	**Object Oriented Analysis and Design**
Course Code	CS324
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	
Pre-requisites	**Programming Fundamentals, Software Engisoftneering**

Course Introduction

he Object Oriented Analysis & Design course focuses on the fundamental concepts of Object Orientation and UML as part of the Software Development Life Cycle. The course focuses on the core activities and artifacts of Object Orientation and UML when used with various methodologies including XP, Agile and Unified Process. UML 2 notation is used throughout the course.

CLO No.	**Course Learning Outcome**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	To learn aspects of Object-oriented analysis and design.	C	2 (Understand)
CLO-2	To be able to analyze complex computing/ real world problems using object-oriented principles.	C	4 (Analyze)
CLO-3	To be able to design computing/real world problems as object-oriented problems using object-oriented techniques.	C	6 (Create)

Course Outline

Principles of Object Technology. OOP Review. Principles of Modeling. Concept of static, dynamic and functional model, UML modeling and diagrams, OOA&D Overview. OO Development Process. Requirements Engineering, Analysis, and Specification, OO Requirements Engineering Concepts, Use Cases, Prototyping, Class Models. Interaction Diagrams. Architectural and Detailed Design. Class Diagrams. Interaction Diagrams. State Machines and Diagrams. Implementation, Package Diagrams. Activity Diagrams. OO Patterns, Object Oriented Design (OOD), Principles of OOD, SOLID (Single-responsibility Principle, Open-Closed Principle, Liskov Substitution Principle, Interface Segregation

Principle, Dependency Inversion Principle), Designing Data Model (ERD), Relationships and associations. Mapping Concepts, O/R Mapping, Shadow information and Scaffolding, Mapping metadata, Mapping inheritance, Mapping object relationships, Mapping relational database relationships.

Reference Material

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

1. Larman, Craig. Applying UML and Patterns: An Introduction to Object Oriented Analysis and Design and Iterative Development 3rd Edition. Pearson Education India, 2012
2. Seidl, Martina, et al. UML @ Classroom. Springer, 2015
3. Ramnath, Sarnath, and Brahma Dathan. Object-Oriented Analysis and Design. Springer Science and Business Media, 2010
4. Stevens, Perdita, and R. J. Pooley. Using UML. 3rd Edition, Pearson Education, 2006
5. Page-Jones, Meiler. Fundamental of Object-Oriented Design in UML. Addison Wesley, 2000. ISBN 020169946X.
6. Booch, G, Rambaugh, J and Jakobson, I. The Unified Modeling Language User Guide. Addison-Wesley Professional; 2nd Edition (2005). ISBN- 10 0321267974.

Course Name	**Theory of Automata**
Course Code	CS311
Course Area	Domain Core
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. Cohen, Daniel. Introduction to Computer Theory. New York, Wiley, 1997.
2. Kelley, Dean. Automata and Formal Languages an introduction. Prentice-Hall, Inc., 1995.
3. Sipser, Michael. Introduction to the Theory of Computation. Cengage Learning, 2013.
4. Esparza, Javier, and Michael Blondin. Automata Theory. MIT Press, 2023.

Course Name	**Advanced Database Management Systems**
Course Code	CS301
Course Area	Domain Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Database Systems

Course Introduction

This course is designed for students seeking career in database designing to master some of the advanced concepts of database systems.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Understanding advance data models, technologies and approaches for building distributed database systems.	C	2 (Understand)

CLO-2	Applying the models and approaches to become enabled to select and apply appropriate methods for a particular case.	C	3 (Analyze)
CLO-3	To develop a database solution for a given scenario/ challenging problem in the domain of distributed database systems.	C	3 (Evaluate)

Course Outline

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

Reference Material

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

1. Coronel, Carlos, and Steven Morris. Database systems design, implementation and management. Cengage learning, 2019.
2. Ramakrishnan, Raghu, and Johannes Gehrke. Database management systems. McGraw-Hill, Inc., 2002.
3. Elmasri, Ramez. Fundamentals of database systems. Pearson Education India, 2008.
4. Hoffer, Jeffrey A, et al. Modern Database Management. Boston, Pearson, 2016.
5. Silberschatz, Abraham. Database System Concepts. New York Mcgraw-Hill Education, 2020.

Course Name	**Artificial Intelligence for Software Engineering**
Course Code	**CS405**
Course Area	**Domain Electives**
Credit Hours	**3 (2-3)**
Contact Hours	**3-0**
Pre-requisites	**Artificial Intelligence, Software Engineering**

Course Introduction

This course is designed to bridge the gap between Artificial Intelligence (AI) and Software Engineering (SE). Students will explore how AI techniques can be applied to solve complex problems in software development, testing, maintenance, and project management. The course emphasizes the practical integration of AI into SE practices, preparing students to leverage AI tools and methodologies to enhance software quality, efficiency, and innovation.

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

		Domain	Level
CLO-1	Apply AI techniques to automate software engineering tasks, including requirements analysis, design, coding, testing, and maintenance.	C	2 (Understand)
CLO-2	Analyze and evaluate AI-driven tools and methodologies in the context of software engineering processes.	C	3 (Apply)
CLO-3	Design and develop AI-based solutions for specific challenges in software development, such as bug detection, code generation, and project management.	C	3 (Apply)
CLO-4	Demonstrate understanding of ethical considerations and best practices in integrating AI with software engineering.	C	3 (Apply)

Course Outline

Introduction to AI, Knowledge Representation, Problem Solving by Searching, Introduction to AI in Software Engineering, Machine Learning (Unsupervised learning, Supervised learning, Reinforcement learning); Uncertainty handling (Uncertainty in AI, Fuzzy logic rules, reasoning and different inference methods). AI-driven Software Development Life Cycle (SDLC), AI for Requirements Analysis and Specification, Automated Software Design with AI, Machine Learning for Code Generation, Generative AI, Introduction to Transformers, Transformers and Code, Generating code with chatbots, AI in Software Testing and Quality Assurance, AI-driven test case generation, AI-powered test automation, predictive analytics in software testing, AI for defect detection and classification, AI in regression and performance testing, Natural Language Processing (NLP) in Software Engineering, AI for Software Maintenance and Evolution, Role of LLMs in Software Development, Generative AI for Software Development, fixing bugs using LLMs, Ethical and Social Implications of AI in Software Engineering.

Reference Material

1. Harman, Mark, and Tim Menzies. Artificial Intelligence for Software Engineering Quality Improvement and Testing Automation. 1st ed., Springer, 2021.
2. Liu, Xiaodong, Zakwan Jaroucheh, and Yuchen Zhao. Artificial Intelligence in Software Engineering Challenges and Opportunities. 1st ed., Springer, 2022.
3. Henkel, Jörg, Sören Frey, and Xiaoming Zheng. AI for Software Engineering Building Intelligent Software with Machine Learning. 1st ed., Wiley, 2023.

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 Outcome	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	Web Engineering
Course Code	CS349
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Object Oriented Programming

Course Introduction

The World Wide Web has become a major delivery platform for information resources. Web Engineering introduces a structured methodology utilized in software engineering to web development projects. This course examines systematic, disciplined and quantifiable approaches to developing of high-quality, reliable and usable web applications. The course addresses the concepts, methods, technologies, and techniques of developing Web sites that collect, organize and expose information resources.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Understand concepts, principles & methods of Web engineering.	C	2 (Understand)
CLO-2	Apply the principles, and methods of Web engineering to Web applications development.	C	3 (Apply)
CLO-3	Analyze and design comprehensive systems for the creation, dissemination, storage, retrieval, and use of electronic records and documents.	C	4 (Analyze)
CLO-4	Learn techniques and evaluation metrics for ensuring the proper operability, maintenance and security of a web application.	C	2 (Understand) &5(Evaluation)

Course Outline

Categories of Web Applications, Characteristics of Web Applications, Product-Related and Usage-Related and Development-Related Characteristics, Requirements Engineering Activities Specifically Web Engineering, Principles for Requirements Engineering of Web Applications, Adapting Requirements Engineering Methods to Web Application Development, Modelling Specifics in Web Engineering, Design Guidelines, Web Usability Engineering Methods, Web Usability Engineering Trends, Client/Server Communication on the Web, Client-side Technologies, Document-specific Technologies, Server-side Technologies (URI Handlers, Web Services, Middleware Technologies), Web Application Development Process, Parallel Development of Different Releases, Analysis of the Rational Unified Process, Analysis of Extreme Programming, Software Project Management to Web Project Management, Challenges in Web Project Management, Managing Web Teams, Managing Development Process of Web Application.

Reference Material

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

1. Rajiv Chopra. Web Engineering. Delhi, Phi Learning Private Limited, 2016.
2. Suh, Woojong. Web Engineering. IGI Global, 2005.
3. Pressman, Roger, and David Lowe. Web Engineering A Practitioner's Approach. McGraw-Hill Science, Engineering & Mathematics, 2009.

Course Name	**Cyber Security**
Course Code	CS303

Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Information Security

Course Introduction

This course provides students with an introduction to common cyber security threats, vulnerabilities, and risks related to web applications, networks, software and mobile applications. The course provides basic concepts and terminology used in the information and cyber security fields. Moreover, it will also enable students to differentiate between the various forms of malware and how they affect computers and networks.

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	To be able to identify computer system threats	C	2 (Understand)
CLO-2	To be able to identify Malware attacks, and understand the stages of attack and payloads	C	2 (Understand)
CLO-3	Implement various cryptographic techniques and simulate attack scenarios	C	3 (Apply)

Course Outline

Introduction to Cyber security; Networks and the Internet; cyber threat landscape; understanding security; information security Principles (Confidentiality, Integrity, Availability); Information Security Terminology; Who are the attackers; Advanced Persistent Threat (APT); Malware, types of malware; Attacks using malware; Malware Attack Lifecycle Stages of Attack; Social engineering attacks; types of payload; Industrial Espionage in Cyberspace; Basic cryptography; Web application attacks; Database security; Cyber kill chain; Privacy and anonymity; Network security; Software security; Mobile device security; Mobile app security; Cyber Terrorism and Information Warfare; Introduction to Digital Forensics; Digital Forensics Categories.

Reference Material

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

1. Easttom, Chuck. Computer security fundamentals. Pearson IT certification, 2019.
2. Ciampa, Mark D. Security+ Guide to Network Security Fundamentals. Boston, Mass., Course Technology Cengage Learning, 2012.
3. Pfleeger, Charles P, et al. Security in Computing. Hoboken, Pearson Education, 2015.

Course Name	**Software Process Improvement**
Course Code	CS344
Course Area	Domain Electives
Credit Hours	3 (3-0)

Contact Hours	3
Pre-requisites	Software Engineering

Course Introduction

CLO No.	Course Learning Outcome	Bloom's Domain	Taxonomy Level
CLO-1	Understand key concepts of Software Process Improvement (SPI), including the Software Process, Process Assessment, Process Maturity.	C	2 (Understand)
CLO-2	Implement Software Process Improvement in Small and Medium Enterprise (SME)	C	6 (Create)
CLO-3	Analyze various SPI project factors, organizational factors and process-related factors in software industry	C	4 (Analyze)

Course Outline

Introduction (Software Process, Software Process Improvement (SPI), benefits and standard SPI models like Capability Maturity Model Integration (CMMI), ISO/IEC15,504, and Implementation Maturity Model). SPI initiatives in various phases of Software Development Life Cycle (SDLC). Setting-up a CMMI Initiative (Approach to Continuous Improvement, CMMI Improvement Structure and Teams, Planning the Improvement Cycle, Implementation of Improvements). CMMI Level-2 Implementation (Project Management, Supplier Agreement Management, Requirements Development and Management, Configuration Management, Process and Product Quality Assurance, Measurement and Analysis). CMMI Level-3 Implementation (Organization Process Focus, Organization Process Definition, Organization Training, Requirements, Design, and Development, Verification and Validation, Integrated Project Management, Risk Management, Decision Analysis and Resolution). CMMI Level 4 and 5 Implementation (Organization Process Performance, Quantitative Project Management, Organization Innovation and Deployment). Project Management Maturity, GSD Overview of Outsourcing Models, Agile Practices for SPI, Agile Maturity Model.

Reference Material

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

1. Buede, D. M., & Miller, W. D. The engineering design of systems models and methods. John Wiley & Sons, 2024.
2. O'Regan, G. *Introduction to software process improvement*. Springer Science & Business Media, 2010.

Course Name	Business Process Analysis
Course Code	CS406
Course Area	Domain Electives
Credit Hours	3(2-3)
Contact Hours	2-3
Pre-requisites	None

Course Introduction

This course provides an in-depth understanding of the role of business processes in effectively and efficiently managing business operations. This course aims to teach students the key concepts of business process analysis, modelling and management, and their importance to an organization. Students gain essential skills of the entire Business Process Management (BPM) lifecycle, from process identification and design to process monitoring, including process modelling, analysis, redesign, and automation required to achieve high performance and deliver the strategy in a service-oriented environment. Students also gain highly sought after practical skills of using BPM tools to recommend improvements by documenting and simulating current and new processes.

CLO No.	Course Learning Outcome	Bloom's Taxonomy Domain	Level
CLO-1	Discuss the role of Business Process Management (BPM) in a business environment and how BPM initiatives contribute to improving the overall business performance	C	2 (Understand)
CLO-2	Apply the BPM principles, concepts, and frameworks to business problems and practice as captured in the BPM lifecycle	C	3 (Apply)
CLO-3	Analyze how process improvement technologies and business process management support the enhancement of an organization's business objectives. Address the issues and challenges associated with process improvement initiatives in organizations	C	4 (Analyze)
CLO-4	Evaluate the impact of process design and redesign decisions on stakeholders and the role of change management in addressing the risks associated with such changes in organizations	C	5 (Evaluate)

Course Outline

Introduction to Business Process Management (BPM) and its relationship to organizational strategic planning. Organizational concepts, BPM approaches and methodologies. Business process modelling levels 1 & 2 Palette using the Bizagi modelling tool. Business process architecture and business value creation. Business process design best practices, Lean Methodology and process improvement. Resources allocation and capacity, performance analysis. BPM technologies, BPMS and Business Process Automation. Change management, quality assurance, Six Sigma and the future of BPM.

Reference Material

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

1. Darnton, Geoffrey, and Moksha Darnton. Business Process Analysis. Pub Cengage Learning Emea,1997.

2. Brennan, Kevin. A guide to the Business analysis body of knowledge (BABOK guide). 3rd Edition. International Institute of Business Analysis Publisher, 2015.
3. Haines, Steven, and Bill Wear. The product manager's desk reference. 3rd Edition, New York McGraw-Hill, 2021.

Course Name	**Software Testing and Quality Assurance**
Course Code	CS325
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Programming Fundamentals, Software Engineering

Course Introduction

Testing is a critically important part of software development and delivery. This course will give you a broad introduction to the established practices and approaches to testing and improving the quality of software products.

CLO No.	**Course Learning Outcomes**	**Bloom's Taxonomy Domain**	**Level**
CLO-1	Understand and explain the key concepts and principles of software testing	C	2(Understand)
CLO-2	Describe, plan and apply various testing techniques	C	3(Apply)
CLO-3	Specify and perform the activities involved in a testing process	C	3(Apply)

Course Outline

Concept and difference between software verification and validation, Testing techniques. Black Box testing, White Box and Grey Box testing techniques. Quality Assurance planning and execution. Automated testing topics include constructing a framework, scripting techniques, generating a test data, generating test architecture, pre/post-processing, test maintenance, and job specific metrics. Introduction to latest trends and tools used for Software Testing and Quality Assurance.

Reference Material

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

1. Jorgensen, Paul C., and Byron DeVries. Software Testing. Auerbach Publications 2021
2. Abu Sayed Mahfuz. Software Quality Assurance Integrating Testing, Security, and Audit. Boca Raton, Auerbach, 2020.
3. Utting, Mark, and Bruno Legeard. Practical model-based testing a tools approach. Elsevier, 2010.
4. Tian, Jeff. Software quality engineering testing, quality assurance, and quantifiable improvement. John Wiley & Sons, 2005.
5. Ammann, Paul, and Jeff Offutt. Introduction to Software Testing. Cambridge, United Kingdom ; New York, Ny, Usa, Cambridge University Press, 2017.

Course Name	**Technology Trends in Software Engineering**
Course Code	CS339
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	5
Pre-requisites	Software Engineering

Course Introduction

This course is aimed at introducing the advanced and ever changing state of Software Engineering research and development around the world. The goal is to keep the students up-to-date with latest technology so that they come become readily integrated into the industry after graduation

CLO No.	**Course Learning Outcome**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	To learn about latest trends in software development industry.	C	2 (Understand)
CLO-2	Understand the implementations details of the new technology in software engineering projects	C	4 (Analyze)
CLO-3	Develop software systems using new technology	C	3 (Apply)

Course Outline

Introduction to the latest trends in Software Engineering and professional software development. The topics include but not limited to AI and ML(AI-augmented software development**)**, Progressive Web Apps, Software Engineering aspects in Internet of Things (IoT), Blockchain (Blockchain-oriented software (BOS) systems), Cybersecurity, Cloud Computing, Low-Code/No-Code Development, Quantum Computing. Concept of DevOps and development, security, and operations (DevSecOps) and environments. GitHub/GitLab. The instructor may choose at least two major and two minor topics as main content of the course.

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

1. Khan, S. A., Kumar, R., Ahmad Khan, R. (2023). Software Security Concepts & Practices. United Kingdom CRC Press
2. Hopgood, Adrian A. 2021. Intelligent systems for engineers and scientists a practical guide to artificial intelligence. CRC press, 2021.
3. Latest related books and internet sources.

Course Name	**Sustainability Aspects in Software Engineering**
Course Code	CS414
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Software Design and Architecture

Course Introduction

This course will cover a set of competencies needed to leverage sustainable software systems. The course aims to provide sufficient exposure to different components of sustainability issues in software development life cycle.

CLO No.	**Course Learning Outcome**	**Bloom's Taxonomy**	
		Domain	**Level**
CLO-1	Discuss sustainability principles	C	2 (Understand)
CLO-2	Identify sustainability issues in real software projects.	C	4 (Analyze)
CLO-3	Apply knowledge to design sustainable software	C	3 (Apply)

Course Outline

Understanding of Sustainability and Green Software Principles Environmental Impact, Social Responsibility, Economic Viability. Green Software Practices Energy Efficiency, Resource Efficiency. Lifecycle Thinking Design for Longevity, Maintenance and Updates. Sustainable Development Processes Awareness of Current Trends and Tools for Sustainability and making right choices for software development Agile Practices Employ agile methodologies to adapt quickly to changes and incorporate feedback efficiently, Concept of DevOps and Continuous Integration/Continuous Deployment (CI/CD), Code Quality and Best Practices Green coding and green data management including familiarity with techniques and tools for measuring and optimizing software performance and Energy usage, use of Design

Patterns, Modularity and Reusability, Testing and Validation, Sustainability Metrics, Collaboration and Stakeholder Engagement, Cross-Disciplinary Collaboration, User Involvement, Ethical Considerations, Real-world examples of sustainable software practices. Hands-on projects to apply concepts.

Reference Material

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

1. Tate, Kevin. Sustainable Software Development An Agile Perspective. 2005, ci.nii.ac.jp/ncid/BA77153802.
2. Mohankumar, M. New Approach For Sustainable Software Engineering Using Green Techonologies.2023

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.

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 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 at the senior level need 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 provides useful knowledge to the students for writing proposals etc. Further, the course aims at augmenting students' proficiency in technical writing 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 a 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 Software Engineering Elective Supporting Courses

This Software Engineering **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 Software Engineering General Education Courses

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, George, and Finney, Ross. Calculus and Analytic, 10th Edition. Addison Wesley. 2000.
2. Swokowski, Earl. Calculus and Analytical Geometry, 6th Edition. Brooks/Cole Publishers. 1994.
3. Stewart, James. Calculus, 8th Edition. Cengage Learning. 2015

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, Muhammad. Introduction to Islam. Truestar, 1997
2. Hassan, Ahmad. Principles of Islamic Jurisprudence. Islamic Research Institute.
3. Waliullah, Mir. Muslim Jurisprudence and the Quranic Law of Crimes. Islamic Books Services. 1990

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. Rabbani, Muhammad Ikram. A Comprehensive Book of Pakistan Studies. 3rd Edition., The Caravan Press, 2001..

Course Name	**Professional Practices**
Course Code	
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	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.

Course Name	**Entrepreneurship**
Course Code	BA565
Course Area	General Education
Credit Hours	2 (2-0)
Contact Hours	2-0
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	Level
CLO-1	Identify and assess sources of support for small businesses and entrepreneurs and identify the critical factors that are used to identify business start-up ideas – including forms of ownership	C	2 (Understand)
CLO-2	Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture	C	2 (Understand)
CLO-3	Identify the critical concepts of business planning and increase chances of business success	C	4 (Analyze)
CLO-4	Discuss examples of current entrepreneurs.		

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, citizensh community engagement. In this course, the students will learn about the essentials of civil s government, civic responsibilities, inclusivity, and effective ways to participate in shaping the which will help them apply theoretical knowledge to the real-world situations to make a positive on their communities.

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

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 the 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	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**

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.