BS Computer Science Curriculum

2023-24

This document contains the revised curriculum for Bachelor of Science in Computer Science (BSCS), developed according to the NCEAC 2023 Curriculum and HEC Undergraduate Education Policy 2023.

Department of Computer Science

Shaheed Benazir Bhutto University, Sheringal

Table of Contents

1. Bachelor of Science in Computer Science - BSCS

Computer science is the study of the theory, experimentation, and engineering that form the basis for the design and use of computers. It is the scientific and practical approach to computation and its applications and the systematic study of the feasibility, structure, expression, and mechanization of the methodical procedures (or algorithms) that underlie the acquisition, representation, processing, storage, communication of, and access to information [*WordNet Princeton*, NCEAC 2023].

Computer Science is the application of a systematic, disciplined, and quantifiable approach to the design, development, operation, and maintenance of software systems. It is the practice of designing and implementing large, reliable, efficient, and economical software by applying the principles and practices of engineering. The program aims to train students in all aspects of the software life cycle from specification through analysis and design to testing, maintenance, and evaluation of software products [NCEAC 2023].

Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas. The overall scope of Computer Science may be viewed into three categories [NCEAC 2023]: i) To develop effective ways to solve computing problems. ii) To devise new ways to use computers intelligently and effectively. iii) To design and implement software systems. The Bachelor of Science in Computer Science (BSCS) is a 135 credit hours program covering almost all the major areas of Computer Science. The program details are given in the following subsections.

1.1. Program Educational Objectives (PEOs)

We aim to achieve the following PEOs at the end of the BSCS program.

- PEO-1: Graduates apply their in-depth Computer Science knowledge and technical skills in developing software, mobile, or web applications in real-world settings.
- PEO-2: Graduates practice ethics and responsibility in their profession and act as informed citizens in making a socio-economic impact on society.
- PEO-3: Graduates demonstrate lifelong learning skills in Computer Science and allied disciplines.
- PEO-4: Graduates demonstrate leadership and work as good team players in communicating and collaborating in diverse teams and organizations.

1.2. Graduate Attributes (GA)

We aim to attain education objectives by ensuring that students demonstrate achievement of the following Graduate Attributes (GA) [derived from Graduate Attributes defined by Seoul Accord (SA) www.seoulaccord.org] [NCEAC 2023].

- **Academic Education:** To prepare graduates as computing professionals.
- **Knowledge for Solving Computing Problems:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

- **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.
- **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.
- **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.
- **Individual and Team Work:** Function effectively as an individual and as a member or leader in diverse teams and multi-disciplinary settings.
- **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.
- **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.
- **Ethics:** Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.
- **Life-long Learning:** Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

1.3. Curriculum Model for BS Computer Science

Table 1 shows the generic structure for the BSCS program, formulated by following NCEAC Curriculum 2023 and UGE Policy 2023.

Table 1. Generic Structure for BS Computer Science

NCEAC Requirement	UGE Requirement	Credit Hours	Total Credit Hours	Courses
Computing Core	Major (Minimum 72 Credit Hours)	40	85	14
Domain Core		18		6
Domain Elective		21		7
Final Year Project I & II (Computing Core)	Capstone Project (Major)	6		-
Mathematics & Supporting Courses	Interdisciplinary/Allied Courses	12	12	4
Elective Supporting	Minor (Optional)	3	3	1
General Education Courses	General Education Requirement	32	32	13
-	Field Experience/Internship	3	3	-
Deficiency Non-credit Courses for FSc Pre-Medical Students	Mathematics A 0(3-0) & Mathematics B 0(3-0), i.e., 3 contact hours per course per week	0	0	2

Tajweed, Quran and Hadith (Compulsory, nor-credit courses, only for Muslim students) – 1 contact hour per week in each semester		0	0	8
Total Credit Hours			135	55 (45 Cr. Courses)
Double Major (Optional)	-	-		-
Minor (Optional)	-	-		-

Table 2: Mapping of BS Computer Science Scheme

#	Sem#	C. Code	Pre-Reqs	Course Title	Domain	Cr. Hr. (Cont. Hr.)
Computing Core (46/135) 14 Courses (CC for short)						
1.	1	CS112	-	Programming Fundamentals (PF)	CC	4 (3-3)
2.	2	CS115	PF	Object Oriented Programming (OOP)	CC	4 (3-3)
3.	2	CS221	PF	Data Structures (DS)	CC	4 (3-3)
4.	2	CS134	-	Digital Logic Design (DLD)	CC	3 (2-3)
5.	3	CS251	-	Database Systems	CC	4 (3-3)
6.	3	CS271	-	Computer Networks (CN)	CC	3 (2-3)
7.	3	CS261	OOP	Artificial Intelligence	CC	3 (2-3)
8.	3	CS231	DLD	Computer Organization & Assembly Language (COAL)	CC	3 (2-3)
9.	4	CS354	-	Information Security	CC	3 (2-3)
10.	4	CS291	-	Software Engineering (SE)	CC	3 (2-3)
11.	5	CS381	DS	Operating Systems	CC	3 (2-3)
12.	7	CS421	DS	Analysis of Algorithms	CC	3 (3-0)
13.	7	CS401	-	Capstone Project-I (Final Year Project – I)	CC	2 (0-6)
14.	8	CS402	CP-I/FYP-I	Capstone Project-I (Final Year Project – II)	CC	4 (0-12)
Domain Core (18/135) 6 Courses (DC for short)						
15.	4	CS321	-	Theory of Automata	DC	3 (3-0)
16.	4	CS351	DB	Advanced Database Management Systems	DC	3 (2-3)
17.	5	CS345	ICT, PF	HCI & Computer Graphics	DC	3 (2-3)
18.	5	CS232	COAL	Computer Architecture	DC	3 (2-3)
19.	6	CS416	TA	Compiler Construction	DC	3 (2-3)
20.	6	CS385	OS, OOP	Parallel & Distributed Computing	DC	3 (2-3)
Domain Elective (21/135) 7 Courses (DE for short)						
21.	5-8	CS411	OOP	Advanced Programming (AP)	DE	3 (2-3)
22.	5-8	CS376	CN	Cloud Computing	DE	3 (2-3)
23.	5-8	CS455	IS	Digital Forensics	DE	3 (2-3)
24.	5-8	CS343	CAG, LA, AI	Digital Image Processing	DE	3 (2-3)
25.	5-8	CS322	DS	Graph Theory and Its Applications	DE	3 (2-3)
26.	5-8	CS451	IS	Introduction to Cyber Security (ICS)	DE	3 (2-3)
27.	5-8	CS464	IDS	Introduction to Data Mining	DE	3 (2-3)
28.	5-8	CS363	AI	Introduction to Data Science (IDS)	DE	3 (2-3)
29.	5-8	CS362	AI	Machine Learning	DE	3 (2-3)
30.	5-8	CS313	AP	Mobile Application Development – I	DE	3 (2-3)
31.	5-8	CS314	MAD-I	Mobile Application Development – II	DE	3 (2-3)
32.	5-8	CS461	AI	Natural Language Processing	DE	3 (2-3)
33.	5-8	CS391	OOP	Object-Oriented Analysis & Design	DE	3 (2-3)
34.	5-8	CS365	PF, WT	Semantic Web	DE	3 (2-3)
35.	5-8	CS491	SE	Software Project Management	DE	3 (2-3)
36.	5-8	CS392	SE	Software Testing and Quality Assurance	DE	3 (2-3)
37.	5-8	CS492	WT, SE	Web Engineering	DE	3 (2-3)
38.	5-8	CS311	PF	Web Technologies	DE	3 (2-3)
Interdisciplinary/Allied (Mathematics & Supporting) Courses (12/135) 4 Courses						
39.	2	MCC321	CAG	Linear Algebra	Maths	3 (3-0)
40.	2	CAC331	-	Probability & Statistics	Maths	3 (3-0)
41.	5	MCC431	CAG	Multivariable Calculus	Maths	3 (3-0)
42.	8	CS405	FE	Technical & Business Writing	EW	3 (3-0)
Field Experience/Internship						
43.	7	CS301	-	6-8 weeks, can be completed in winter vacations	UGE	3(0-3)
Elective Supporting Courses (3/135) 1 Course (ESC for short)						
44.	7	MS312	-	Introduction to Marketing (Social Sciences)	SS	3 (3-0)

General Education Requirement as per HEC UG Education Policy (32/135) 13 Courses (GE for short)						
45.	1	CS101	-	Application of Information & Communication Technologies (ICT)	GE	3 (2-3)
46.	1	ENG311	-	Functional English (FE)	GE	3 (3-0)
47.	1	GQC311	-	Calculus and Analytic Geometry (Quantitative Reasoning – I)	GE	3 (3-0)
48.	1	CS121	-	Discrete Structures (Quantitative Reasoning – II)	GE	3 (3-0)
49.	1	ISL321	-	Islamic Studies	GE	2 (2-0)
50.	2	PS321	-	Ideology and Constitution of Pakistan	GE	2 (2-0)
51.	2	CAC332	-	Applied Physics (Natural Sciences)	GE	3 (2-3)
52.	3	PS325	-	Pakistan Studies	GE	2 (2-0)
53.	3	ENG321	FE	Expository Writing	GE	3 (3-0)
54.	3	PS425	-	Civics and Community Engagement	GE	2 (2-0)
55.	4	MS312	-	Introduction to Management (Social Sciences)	GE	2 (2-0)
56.	4	CS302	-	Professional Practices (Arts & Humanities)	GE	2 (2-0)
57.	4	GE441	-	Entrepreneurship	GE	2 (2-0)
Deficiency Courses						
1.	1	MNC317	-	Mathematics A for Pre-Medical Students	Deficiency Course	0 (3-0)
2.	2	MNC327	Maths A	Mathematics B for Pre-Medical Students		0 (3-0)
Tajweed, Quran and Hadith (TQH for short)						
3.	1	ISL313	-	Tajweed Ul Quran	TQH	0 (1-0)
4.	2	ISL324	-	Understanding Quran-I: Selected Verses		0 (1-0)
5.	3	ISL434	-	Understanding Quran-II: Selected Verses		0 (1-0)
6.	4	ISL445	-	Understanding Quran-III: Selected Verses		0 (1-0)
7.	5	ISL557	-	Understanding Quran-IV: Selected Verses		0 (1-0)
8.	6	ISL567	-	Understanding Quran-V: Selected Verses		0 (1-0)
9.	7	ISL677	-	Seerah-I		0 (1-0)
10.	8	ISL686	-	Seerah-II		0 (1-0)

1.4. Study Plan for BS Computer Science

Table 3 presents the study plan for BS Computer Science, with the following distribution:

Sem 1 + Sem 3 + Sem 5 + Sem 7 = Theory 57 hours + Lab 42 hours + Project Lab 06 hours

Sem 2 + Sem 4 + Sem 6 + Sem 8 = Theory 59 hours + Lab 33 hours + Project Lab 12 hours

Table 3: Study Plane for BS Computer Science

S. No.	Code	Pre-Reqs	Course Title	Domain	Cr Hr. (Cont. Hr.)
Semester 1					
1.	CS101	-	Application of Information & Communication Technologies	GE 1	3 (2-3)
2.	CS112	-	Programming Fundamentals (PF)	CC 1	4 (3-3)
3.	GQC311	-	Calculus and Analytic Geometry (CAG -QR I)	GE 3	3 (3-0)
4.	CS121	-	Discrete Structures (QR II)	GE 2	3 (3-0)
5.	ENG311	-	Functional English	GE 4	3 (3-0)
6.	ISL321	-	Islamic Studies	GE 5	2 (2-0)
7.	MNC317	-	Mathematics A for Medical Students	Deficiency Course 1	0 (3-0)
8.	ISL313	-	Tajweed Ul Quran	TQH 1	0 (1-0)
				Total Credit Hours	**18 (20-6)**
Semester 2					
9.	CS115	PF	Object Oriented Programming (OOP)	CC 2	4 (3-3)
10.	MCC321	CAG	Linear Algebra	Maths 1	3 (3-0)
11.	CS134	-	Digital Logic Design (DLD)	CC 3	3 (2-3)
12.	PS321	-	Ideology and Constitution of Pakistan	GE 6	2 (2-0)
13.	CAC331	-	Probability & Statistics	Maths 2	3 (3-0)
14.	CAC332	-	Applied Physics (Natural Sciences)	GE 7	3 (2-3)
15.	MNC327	Maths A	Mathematics B for Medical Students	Deficiency Course 2	0 (3-0)

16.	ISL324	-	Understanding Quran-I: Selected Verses	TQH 2	0 (1-0)
				Total Credit Hours	**18 (19-9)**
Semester 3					
17.	CS221	PF	Data Structures (DS)	CC 4	4 (3-3)
18.	CS261	OOP	Artificial Intelligence	CC 5	3 (2-3)
19.	PS425	-	Civics and Community Engagement	GE 8	2 (2-0)
20.	CS231	DLD	Computer Organization & Assembly Language (COAL)	CC 6	3 (2-3)
21.	CS271	-	Computer Networks	CC 7	3 (2-3)
22.	ENG321	FE	Expository Writing	GE 9	3 (3-0)
23.	ISL434	-	Understanding Quran-II: Selected Verses	TQH 3	0 (1-0)
					18 (15-12)
Semester 4					
24.	CS251	-	Database Systems	CC 8	4 (3-3)
25.	CS291	-	Software Engineering	CC 9	3 (3-0)
26.	CS232	COAL	Computer Architecture	DC 1	3 (2-3)
27.	PS325	-	Pakistan Studies	GE10	2 (2-0)
28.	MS312	-	Introduction to Management (Social Science)	GE 11	2 (2-0)
29.	CS302	-	Professional Practices (Arts & Humanities)	GE 12	2 (2-0)
30.	GE441	-	Entrepreneurship	GE 13	2 (2-0)
31.	ISL445	-	Understanding Quran-III: Selected Verses	TQH 4	0 (1-0)
				Total Credit Hours	**18 (17-6)**
Semester 5					
32.	CS381	DS	Operating Systems	CC 10	3 (2-3)
33.	CS351	DB	Advanced Database Management Systems	DC 2	3 (2-3)
34.	CS345	ICT, PF	HCI & Computer Graphics	DC 3	3 (2-3)
35.	CSxxx		Domain Elective	DE 1	3 (2-3)
36.	CS301	-	Field Experience/Internship (6-8 weeks)*	UGE Requirement	3 (0-3)
37.	MCC431	CAG	Multivariable Calculus	Maths 1	3 (3-0)
38.	ISL557	-	Understanding Quran-IV: Selected Verses	TQH 5	0 (1-0)
				Total Credit Hours	**18 (12-15)**
Semester 6					
39.	CS321	-	Theory of Automata	DC 4	3 (3-0)
40.	CS385	OS	Parallel & Distributed Computing	DC 5	3 (2-3)
41.	CSxxx		Domain Elective	DE 2	3 (2-3)
42.	CSxxx		Domain Elective	DE 3	3 (2-3)
43.	CS354	-	Information Security	CC 11	3 (2-3)
44.	CSxxx		Domain Elective	DE 4	3 (2-3)
45.	ISL567	-	Understanding Quran-V: Selected Verses	TQH 6	0 (1-0)
				Total Credit Hours	**18 (14-15)**
Semester 7					
46.	CS401	-	Capstone Project – I (CS-I): Final Year Project-I	CC 12/UGE Requirement	2 (0-6)
47.	CSxxx		Domain Elective	DE 5	3 (2-3)
48.	CS416	TA	Compiler Construction	DC 6	3 (2-3)
49.	CS421	DS	Analysis of Algorithms	CC 13	3 (3-0)
50.	CSxxx		Domain Elective	DE 6	3 (2-3)
51.	ISL676		Seerah-I	TQH 7	0 (1-0)
				Total Credit Hours	**14 (10-15)**
Semester 8					
52.	CS402	CS-I	Capstone Project – II: Final Year Project-II	CC 14/UGE Requirement	4 (0-12)
53.	CS405	FE	Technical & Business Writing	EW	3 (3-0)

54.	CSxxx		Domain Elective	DE 7	3 (2-3)
55.	ES		Introduction to Marketing	ESC 1	3 (3-0)
56.	ISL686		Seerah-II	TQH 8	0 (1-0)
				Total Credit Hours	**13 (9-15)**
					Total Credit Hours in BS Computer Science: 135

***Note:** Although the Field Experience/Internship is in the 5th Semester of the study plan, this is not mandatory. Students should complete Field Experience/Internship in Winter Breaks after the 4th Semester and before the conclusion of the 7th Semester. Students completing Field Experience/Internship in this specified duration will not be marked as repeaters in their BS Transcript.

2. Course Contents for BS Computer Science

The following are the category-wise course contents of BS Computer Science.

2.1. Computing Core Courses

Course Name:	**Programming Fundamentals**
Credit Hours:	4 (3-3)
Contact Hours:	Theory: 3 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	This course provides fundamental concepts of programming to freshmen. The course is a 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 teacher to choose any language for practical/Lab purposes but that must be the latest and market-oriented.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand basic problem-solving steps and logic constructs	C2 (Understand)
CLO-2	Apply basic programing concepts	C3 (Apply)
CLO-3	Design and implement algorithms to solve real-world problems	C3 (Solve)

Course Outline:

Introduction to problem-solving, a brief review of Von-Neumann architecture, Introduction to programming, role of compiler and linker, introduction to algorithms, basic data types and variables, input/output constructs, arithmetic, comparison and logical operators, conditional statements and execution flow for conditional statements, repetitive statements and execution flow for repetitive statements, lists and their memory organization, multi-dimensional lists, introduction to modular programming, function definition and calling, stack rolling and unrolling, string and string operations, pointers/references, static and dynamic memory allocation, File I/O operations.

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

1. Starting out with Programming Logic & Degins, 4th Edition, Tony Gaddis,
2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
3. Object Oriented Programming in C++ by Robert Lafore

4. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Course Name:	**Object Oriented Programming**
Credit Hours:	4 (3-3)
Contact Hours:	Theory: 3 Hours, Practical: 3 Hours
Pre-requisites:	Programming Fundamentals
Course Introduction:	The course aims to focus on object-oriented concepts, analysis and software development. The basic concepts of OOP are covered in this course.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the principles of the object-oriented paradigm.	C2 (Understand)
CLO-2	Identify the objects & their relationships to build object-oriented solutions.	C3 (Identify)
CLO-3	Model a solution for a given problem using object-oriented principles.	C3 (Apply)
CLO-4	Examine an object-oriented solution.	C4 (Examine)

Course Outline:

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

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

1. Java: How to Program, 9th Edition by Paul Deitel
2. Beginning Java 2, 7th Edition by Ivor Horton
3. An Introduction to Object Oriented Programming with Java, 5th Edition by C. Thomas Wu
4. Starting Out with C++ from Control Structures to Objects, 9th Edition, Tony Gaddis
5. C++ How to Program, 10th Edition, Deitel & Deitel.
6. Object Oriented Programming in C++, 3rd Edition by Robert Lafore.

Course Name:	**Data Structures**
Credit Hours:	4 (3-3)
Contact Hours:	Theory: 3 Hours, Practical: 3 Hours
Pre-requisites:	Programming Fundamentals
Course Introduction:	The course is designed to teach students structures and schemes, which allow them to write programmer to efficiently manipulate, store, and retrieve data. Students are exposed to the concepts of time and space complexity of computer programs.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Implement various data structures and their algorithms and apply them in implementing simple applications	C3 (Apply)
CLO-2	Analyze simple algorithms and determine their complexities.	C5 (Analyze)
CLO-3	Apply the knowledge of data structure to other application domains.	C3 (Apply)
CLO-4	Design new data structures and algorithms to solve problems.	C6 (Design)

Course Outline:

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

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

1. Data Structures and Algorithm Analysis in Java by Mark A. Weiss
2. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
3. Data Structures and Algorithms in C++ by Adam Drozdek
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss
5. Java Software Structures: Designing and Using Data Structures by John Lewis and Joseph Chase

---

Course Name:	**Digital Logic Design (DLD)**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	The course introduces the concept of digital logic, gates and digital circuits. Further, it focuses on the design and analysis of combinational and sequential circuits. It also serves to familiarize the student with the logic design of basic computer hardware components.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits.	C2 (Understand)
CLO-2	Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques.	C5 (Analyze) & C6 (Create)
CLO-3	Apply the acquired knowledge to simulate and implement small-scale digital circuits.	C3 (Apply)
CLO-4	Understand the relationship between abstract logic characterizations and practical electrical implementations.	C2 (Understand)

Course Outline:

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey method), Flip Flops and Latches, Asynchronous and Synchronous

circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Mealy machines and Moore machines. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA) Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.

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

1. Digital Fundamentals by Floyd, 11/e.
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e.
3. Morris, Mano. Digital Logic and Computer Design, 6th edition. Pearson Education India, 2009.
4. Floyd, Thomas. Digital Computer Electronics, 11th edition. Pearson Education India, 2014.
5. Mazumder, Pinaki, and Idongesit E. Ebong. Lectures on Digital Design Principles.
6. River Publishers, 2023.

Course Name:	**Database Systems**
Credit Hours:	4 (3-3)
Contact Hours:	Theory: 3 Hours, Practical: 3 Hours
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 models and DBMS concepts.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Explain fundamental database concepts.	C2 (Explain)
CLO-2	Design conceptual, logical and physical database schemas using different data models.	C5 (Design)
CLO-3	Identify functional dependencies and resolve database anomalies by normalizing database tables	C2 (Identify)
CLO-4	Use Structured Query Language (SQL) for database definition and manipulation in any DBMS	C4 (Use)

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

1. Connolly, Thomas. Database Systems: A Practical Approach to Design, Implementation, and Management. 6th Edition. Pearson India, 2019.
2. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom
3. Garcia-Molina, Hector. Database Systems: The Complete Book. 2nd Edition. Pearson, 2008.
4. Sudarshan, S, et al.. Database System Concepts, 7th Edition. Generic, 2021.
5. Ramakrishnan, Raghu, and Gehrke, Johannes. Database Management Systems, 3rd Edition. Mc Graw Hill India, 2014.

Course Name:	**Computer Networks**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	This course introduces the basic concept of computer networks to the students. Network layers, Network models (OSI, TCP/IP) and protocol standards are part of the course.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Describe the key terminologies and technologies of computer networks	C2 (Describe)
CLO-2	Explain the services and functions provided by each layer in the Internet protocol stack.	C2 (Explain)
CLO-3	Identify various internetworking devices and protocols and their functions in a networking	C4 (Identify)
CLO-4	Analyze the working and performance of key technologies, algorithms and protocols	C4 (Analyze)
CLO-5	Build Computer Network on various Topologies	P3 (Build)

Course Outline:

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

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

1. Computer Networking: A Top-Down Approach Featuring the Internet, 6th edition by James F. Kurose and Keith W. Ross, 2016
2. Computer Networks, 6th Edition by Andrew S. Tanenbaum, 2021
3. Data and Computer Communications, 10th Edition by William Stallings
4. Data Communication and Computer Networks, 5th Edition by Behrouz A. Forouzan

Course Name:	**Artificial Intelligence**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
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 Taxonomy

CLO-1	Understand the fundamental constructs of Python programming language.	C2 (Understand)
CLO-2	Understand key concepts in the field of artificial intelligence	C2 (Understand)
CLO-3	Implement artificial intelligence techniques and case studies	C3 (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 Materials (or use any other standard and latest books):

1. Russell, S. and Norvig, P. Artificial Intelligence. A Modern Approach, 3rd ed, Prentice Hall, Inc., 2015.
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.
3. Luger, G.F. and Stubblefield, W.A., AI algorithms, Data Structures, and Idioms in Prolog, LISP, and Java", Pearson Addison-Wesley. 2009.
4. Severance, C.R., 2016. Python for Everybody: Exploring Data using Python 3. CreateSpace Independent Publication Platform.
5. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. Python Programming in Context." Jones & Bartlett Pub.
6. Joshi, P., 2017. Artificial Intelligence with Python. Packt Publishing Ltd.

Course Name:	**Computer Organization and Assembly Language**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	DLD
Course Introduction:	The main objective of this course is to introduce the organization of computer systems and the usage of assembly language for optimization and control. Emphasis should be given to exposing the low-level logic employed for problem-solving while using assembly language as a tool. At the end of the course, the students should be capable of writing moderately complex assembly language subroutines and interfacing them to any high-level language.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Acquire the basic knowledge of computer organization, computer architecture and assembly language.	C2 (Understand)
CLO-2	Understand the concepts of basic computer organization, architecture, and assembly language techniques.	C2 (Understand)
CLO-3	Solve the problems related to computer organization and assembly language.	C3 (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 Materials (or use any other standard and latest books):

1. Computer System Architecture, M. Morris Mano, Latest Edition,
2. Assembly Language Programming for Intel- Computer, Latest Edition
3. Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e), Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University
4. Robert Britton, MIPS Assembly Language Programming, Latest Edition.

Course Name:	**Information Security**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
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 Taxonomy
CLO-1	Explain key concepts of information security such as design principles, cryptography, risk management, and ethics	C2 (Explain)
CLO-2	Discuss legal, ethical, and professional issues in information security	A2 (Discuss)
CLO-3	Apply various security and risk management tools for achieving information security and privacy	C3 (Apply)
CLO-4	Identify appropriate techniques to tackle and solve problems in the discipline of information security	C4 (Identify)

Course Outline:

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

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

1. Computer Security: Principles and Practice, 3rd edition by William Stallings
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord

3. Computer Security, 3rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition

Course Name:	**Software Engineering**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course enables students to understand the basics of software engineering, including software development processes, engineering practices, and the techniques required during professional software development.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Describe various software engineering processes and activates.	C1 (Describe)
CLO-2	Apply the system modeling techniques to model a medium size software systems.	C3 (Apply)
CLO-3	Apply software quality assurance and testing principles to medium size software systems.	C4 (Apply)
CLO-4	Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis.	C2 (Discuss)

Course Outline:

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

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

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

Course Name:	**Operating Systems**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Data Structures
Course Introduction:	To help students gain a general understanding of the principles and concepts governing the functions of operating systems and acquaint students with the layered approach that makes design, implementation and operation of the complex OS possible.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems	C2 (Understand)
CLO-2	Analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues concerning the core functions	C5 (Evaluate)
CLO-3	Demonstrate knowledge in applying system software and tools available in modern operating systems.	C3 (Demonstrate)

Course Outline:

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

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

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

Course Name:	**Analysis of Algorithms**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
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 Taxonomy
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	C2 (Understand)

	different behaviors.	
CLO-2	Determine informally the time and space complexity of simple algorithms. Use big O, Omega, and 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	C3 (Apply)
CLO-3	List and contrast standard complexity classes.	C4 (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.	C5 (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 Materials (or use any other standard and latest books):

1. Introduction to Algorithms (4th Edition) by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, 2022.
2. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos,
3. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne.

Course Name:	**Capstone Project-I (Final Year Project-I)**
Credit Hours:	2 (0-6)
Contact Hours:	Theory: 0 Hours, Practical: 6 Hours
Pre-requisites:	Web Technologies
Course Introduction:	A capstone project is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. The capstone project must be supervised and graded by a faculty member as per the protocols prescribed by the Department of Computer Science.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

Students individually or in groups (of not more than three members) should request a faculty member (who can supervise not more than five projects) of their choice to supervise them in the Capstone Project (Final Year Project). Students have to develop a desktop application/mobile application/web application based a unique idea (not previously done by students in the department). Students should register themselves for such a project at the beginning of this semester with the BS Course Coordinator, who will decide in collaboration with the Head of the Department, whether the project is worth doing and suggesting changes if any. After registering for the project, students must ensure their presence when the concerned supervisor calls upon them. A supervisor must maintain an attendance record and progress report of the student and must produce it upon inquiry by the Head of Department and BS Course

Coordinator.
At the end of Capstone Project-I, students should have completed the first three chapters and some basic functionalities of their targeted project.
Reference Materials (or use any other standard and latest books):

1. Relevant theses, FYPs, Capstone Projects, and papers
2. Any other material suggested by the concerned supervisor

Course Name:	**Capstone Project-II (Final Year Project-II)**
Credit Hours:	4 (0-12)
Contact Hours:	Theory: 0 Hours, Practical: 12 Hours
Pre-requisites:	None
Course Introduction:	A capstone project is a multifaceted body of work that serves as a culminating academic and intellectual experience for students. The capstone project must be supervised and graded by a faculty member as per the protocols prescribed by the Department of Computer Science.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
-	-	-

Course Outline:
Students individually or in groups (of not more than three members) should request a faculty member (who can supervise not more than five projects) of their choice to supervise them in the Capstone Project (Final Year Project). Students have to develop a desktop application/mobile application/web application based a unique idea (not previously done by students in the department). Students should continue working on their approved project and must ensure their presence when the concerned supervisor calls upon them. A supervisor must maintain an attendance record and progress report of the student and must produce it upon inquiry by the Head of Department and BS Course Coordinator.
At the end of Capstone Project-II, students should have completed the whole thesis and all the required functionalities. Students must submit thesis not more than two months after the commencement of the 8th semester exam.
Reference Materials (or use any other standard and latest books):

1. Relevant theses, FYPs, Capstone Projects, and papers
2. Any other material suggested by the concerned supervisor

2.2. Domain Core Courses

Course Name:	**Theory of Automata**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course	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

Introduction:	automata, as the first step towards learning advanced topics, such as compiler design. It will also enable the student to apply 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 Taxonomy
CLO-1	Explain the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, and Turing machines	C2 (Understand)
CLO-2	Prove properties of languages, grammars and automata with rigorously formal mathematical methods	C2 (Understand)
CLO-3	Design of automata, RE and CFG	C3 (Apply)
CLO-4	Transform between equivalent NFAs, DFAs and REs	C3 (Apply)
CLO-5	Define Turing machines performing simple tasks	C2 (Understand)
CLO-6	Differentiate and manipulate formal descriptions of languages, automata and grammars with a focus on regular and context-free languages, finite automata and regular expressions.	C3 (Apply)

Course Outline:

Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: CFGs, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

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

1. Introduction to computer theory, Daniel I. A. Cohen, 2nd Edition
2. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich, 2011
3. An Introduction to Formal Languages and Automata, by Peter Linz, 4th edition, Jones & Bartlett Publishers, 2006
4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Kavier, 2005, New Age Publishers.

Course Name:	**Advanced Database Management Systems**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Database Systems
Course Introduction:	Advanced Database Management Systems is an extension to the "Database Systems" course. The course aims to enhance the previous knowledge of database systems by deepening the understanding of the theoretical and practical aspects of database technologies, and showing the need for distributed database technology to tackle deficiencies of the centralized database systems. Moreover, it focuses on introducing the basic principles and implementation techniques of distributed database systems, and exposes emerging research issues in database systems and application development.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understanding advance data models, technologies and approaches for building distributed database systems.	C2 (Understand)
CLO-2	Applying the models and approaches to become enabled to select and apply appropriate methods for a particular case	C3 (Apply)
CLO-3	To develop a database solution for a given scenario/ challenging problem in the domain of distributed database systems.	C3 (Apply)

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

1. Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition by Thomas Connolly and Carolyn Begg
2. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke
3. Database System Concepts, 6th Edition by Avi Silberschatz, Henry F. Korth and S. Sudarshan.
4. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom.

Course Name:	**HCI & Computer Graphics**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Applications of ICT, Programming Fundamentals
Course Introduction:	This is an introductory course to teach all relevant elements required to understand the basic concepts of HCI and Computer Graphics.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the basics of Human-Computer Interaction and Computer Graphics	C2 (Understand)
CLO-2	Develop Interactive CG programs using OpenGL	C3 (Apply)
CLO-3	Analyze techniques of user-centered design for desktop software, mobile app, or web application	C4 (Analyze)
CLO-4	Evaluate the usability of the user interface of desktop software, mobile app, or web application	C5 (Evaluate)

Course Outline*:

Definition and topics of HCI and computer graphics, history. Human cognition. Human visual system: the human eye, optical illusions, spatial perception, color perception. Colorimetry and color systems. 2D and 3D geometry. Graphical output devices. User Interactions and usability: dialogue techniques, input devices, interaction styles, menus and dialogues, HCI models, design criteria, metaphors. Graphical user interface implementation and evaluation: windows systems, toolkits, event handling, geometry

management, platform-independent GUI development. Augmented reality. Pervasive and ubiquitous applications.

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

1. Computer Graphics with Open GL 4th Edition by Donald D. Hearn, Prentice Hall, 2010.
2. Introduction to Computer Graphics: Using Java 2D and 3D, Springer, 2nd Edition, 2008.
3. Designing the User Interface: Strategies for Effective Human-Computer Interaction by Ben Shneiderman and Catherine Plaisant, 6th Edition, Pearson Inc. 2016.
4. Designing Interactive Systems: A Comprehensive Guide to HCI, UX and Interaction Design by Benyon, D. 3rd Edition, 2023.

*Source: The course of HCI and Computer Graphics was designed in the light of the following sources:

1. M. Rotard, D. Weiskopf, and T. Ertl. A combined introductory course on HCI and Computer Graphics. *Computers and Graphics* **29**(2005):267-272.
2. Reference Materials were taken from *Curriculum of Computer Science, Software Engineering, and Information Technology (Bachelors & Masters Programs) – Revised 2017*, HEC Curriculum Division, HEC Islamabad.

Course Name:	**Computer Architecture**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Computer Organization and Assembly Language
Course Introduction:	Modern computer technology requires an understanding of both hardware and software, as the interaction between the two offers a framework for mastering the fundamentals of computing. This course covers the basics of modern computer organization and architecture. The emphasis is on understanding the interaction between computer hardware and software at various levels. The students will learn the concepts of computer technology, performance evaluation, instruction set design, computer arithmetic, data path and control unit design of processors and enhancing performance with pipelining.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the architecture of modern computing systems, microprocessors, and multiprocessors.	-
CLO-2	Understand implementations of the arithmetic logic unit and control unit, pipelined processor, hazards, memory hierarchy, and storage devices	-
CLO-3	Understand performance analysis and evaluation.	-

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

1. Patterson, D. A., & Hennessy, J. L. (2013). Computer Organization and Design the Hardware/Software Interface (Latest Edition). Morgan Kaufmann.
2. Hennessy, J. L., & Patterson, D. A., (2012). Computer Architecture: A Quantitative Approach (Latest Edition). Morgan Kaufmann.

Course Name:	**Compiler Construction**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Theory of Automata
Course Introduction:	The course is intended to teach the students the basic techniques that underlie the practice of Compiler Construction. The course introduces the theory and tools required in performing syntax-directed translation of a high-level programming language into an executable code. These techniques can also be employed in wider areas of application, whenever we need a syntax-directed analysis of symbolic expressions and languages and their translation into a lower-level description. They have multiple applications for man-machine interaction, including verification and program analysis. The course also discusses various aspects of the run-time environment into which the high-level code is translated. This will provide deeper insights into the more advanced semantic aspects of programming languages, such as recursion, dynamic memory allocation, types and their inferences, object orientation, concurrency and multi-threading.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand programming language concepts deeply.	C2 (Understand)
CLO-2	Understand processing of programming languages by computers.	C2 (Understand)
CLO-3	Have full command on techniques used by translator software	C3 (Apply)

Course Outline:

Introduction to Translators, Compiler, Interpreter, Assembler, Context of Compiler, Pre-processor, Assembler, Linker, Loader, Compiler introduction: Analysis-Synthesis Model of Compiler, Phases of Compiler, Two-Pass Assembly, Physical Organization of Compiler, Cousins of compiler, Compiler-Compilers, Lexical Analysis: Role of Lexical Analyzer, Lexical Error Handling, Buffering Issues in Lexical Analyzer, Lexical Analyzer Implementation (Hand coding, Lex), Syntax Analysis: Introduction to Top-Down and Bottom-Up Parsers, Recursive-Descent Parsers, Predictive Parsers, Non-Recursive Predictive Parser, Shift-Reduce Parser, Operator Precedence Parsers, LR Parsers, LL(1) Grammars, LR(1) Grammars, YACC, Syntax Error Handling, Type Systems, Symbol Table Management, Runtime Environment, Intermediate Code: Triples, Indirect Triples, Quadruples, Symbol Table: Techniques such as Lists and Hash Tables, Code Optimization, Code Generation.

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

1. Watson, D. (2017). A Practical Approach to Compiler Construction (Latest Edition). Springer.

2. Mogensen, T. Æ. (2011). Introduction to compiler design (Latest Edition). Springer Science & Business Media.
3. Dave, P. H., & Dave, H. B. (2012). Compilers: Principles and Practice (Latest Edition). Pearson Education India.
4. Puntambekar, A. A. (2009). Principles of compiler design (Latest Edition). Technical Publications.
5. Cooper, K., & Torczon, L. (2011). Engineering a compiler (Latest Edition). Elsevier.

Course Name:	**Parallel & Distributed Computing**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Object Oriented Programming, Operating Systems
Course Introduction:	This course helps to analyze sequential algorithms for possible modifications and implementation on available advanced machines. It details the study of various parallel and distributed computing hardware, operating system, algorithm design, and implementation techniques.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Learn about parallel and distributed computers.	C2 (Understand)
CLO-2	Write portable programs for parallel or distributed – architectures using a Message-Passing Interface (MPI) library.	C3 (Apply)
CLO-3	Analyze complex problems with shared memory – programming with openMP.	C4 (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 Materials (or use any other standard and latest books):

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

2.3. Domain Elective Courses

The following are domain elective courses that can be offered to BS Computer Science Students.

S. No.	Semester	Course Code	Pre-Requisites	Course Title
1.	5-8	CS411	OOP	Advanced Programming (AP)
2.	5-8	CS376	CN	Cloud Computing
3.	5-8	CS455	IS	Digital Forensics
4.	5-8	CS343	CAG, LA, AI	Digital Image Processing
5.	5-8	CS322	DS	Graph Theory and Its Applications
6.	5-8	CS451	IS	Introduction to Cyber Security (ICS)
7.	5-8	CS464	IDS	Introduction to Data Mining
8.	5-8	CS363	AI	Introduction to Data Science (IDS)
9.	5-8	CS362	AI	Machine Learning
10.	5-8	CS313	AP	Mobile Application Development – I
11.	5-8	CS314	MAD-I	Mobile Application Development – II
12.	5-8	CS461	AI	Natural Language Processing
13.	5-8	CS391	OOP	Object-Oriented Analysis & Design
14.	5-8	CS365	PF, WT	Semantic Web
15.	5-8	CS491	SE	Software Project Management
16.	5-8	CS392	SE	Software Testing and Quality Assurance
17.	5-8	CS492	WT, SE	Web Engineering
18.	5-8	CS311	PF	Web Technologies

Course Name:	**Advanced Programming**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Object Oriented Programming
Course Introduction:	This course exposes students to the depth and breadth of modern programming practice, to make students better programmers. The objective is to introduce the students to some concepts of advanced programming and practice on reusing components. It focuses on Graphical User Interface (GUI), multithreading, networking, and database manipulation. A selected programming language is used such as Java. By completing this course, the students should be able to write sophisticated Java applications.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand some advanced programming concepts to deal with complex data objects.	-
CLO-2	Develop cognitive skills to define and analyze the problem to develop large programs in handling them.	-
CLO-3	Write the simplest possible program that solves a given problem while explaining to the reader how it solves that problem.	-
CLO-4	Develop programs to promote inheritance and reuse, implement networking and multithreading:	-
CLO-5	Compose more complex programs from simpler parts, and	-

write programs that implement GUIs

Course Outline:

Java, Java platform. Java and Object Oriented Programming: Classes, objects, Inheritance, Polymorphism, and Interfaces. Exception Handling. JavaFX Graphical User Interfaces (GUIs). Generic Collections. JavaFX graphics and multimedia. Graphics and Java 2D. Accessing Databases with Java Database Connectivity. Swing GUI components. Networking.

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

1. Java In A Nutshell: A Desktop Quick Reference 8th Edition by Benjamin J. Evans, Jason Clark, and David Flangan. Released February 2023. O'Reilly
2. Java How to Program. 11th Edition. 2017 (or Latest Edition). Pearson
3. Online Java Tutorials and API Documentation

Course Name:	**Cloud Computing**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Computer Networks
Course Introduction:	The course aims to learn tools, techniques and systems related to cloud computing both theoretically and practically. The basic concepts of cloud computing are covered in this course.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand basic concepts of cloud computing.	C2 (Understand)
CLO-2	Identify technical challenges associated with cloud computing.	C3 (Identify)
CLO-3	Address data processing challenges using cloud computing.	C3 (Apply)
CLO-4	Examine cloud computing solutions.	C4 (Examine)

Course Outline:

Overview of Distributed Computing, Emergence of Cloud Computing, Global Nature of the Cloud, Cloud-Based Service Offerings, Grid Computing, Reliability of Cloud Model, Benefits of Cloud Model, Legal Issues, Key Characteristics of Cloud Computing, Challenges for the Cloud. The Evolution of Cloud Computing. Web Services Delivered from the Cloud: Communication-as-a-Service (CaaS), Infrastructure-as-a-Service, Monitoring-as-a-Service (MaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Building Cloud Networks. Virtualization. Federation, Presence, Identity, and Privacy in the Cloud. Security in the Cloud. Common Standards in Cloud Computing. End-User Access to Cloud Computing. Mobile Internet Devices and the Cloud.

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

1. Cloud Computing Implementation, Management, and Security by John W. Rittinghouse and James F. Ransome, Taylor & Francis Group, LLC (2010). ISBN 978-1-4398-0680-7.
2. Cloud Computing Explained: Implementation Handbook for Enterprises by John Rhoton, Recursive Press (2013).
3. Cloud Computing Bible by Barrie Sosinsky, Wiley; 1st Edition (2011). ISBN-10: 0470903562.
4. Securing the Cloud: Cloud Computer Security Techniques and Tactics by Vic (J.R.) Winkler, Syngress; 1st Edition (2011). ISBN-10: 1597495921.Book

Course Name:	**Digital Forensics**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Introduction to Cyber Security
Course Introduction:	This course is an introduction to computer forensics and investigation. It provides an understanding of how to conduct investigations to correctly gather, analyze and present digital evidence to different audiences. It also outlines the tools to locate and analyze digital evidence on a variety of devices, how to keep up to date with changing technologies, and laws and regulations in digital forensics.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To develop knowledge about forensic law, standards, regulations, and ethical values	C2 (Understand)
CLO-2	To be able to conduct digital forensics for multiple platforms and applications by various tools	C3 (Apply)
CLO-3	To be able to generate reports based on digital forensic tools for security systems and platforms	C3 (Apply)

Course Outline:

An introduction to Digital Forensics; use of digital forensics; Key technical concepts; Challenges in Digital Forensics ; The Difference between Computer Experts and Digital Forensics Experts; Investigative Process Methodologies ; Education, Training, and Awareness; Laws, Standards, and Regulations; Ethics and Professional Conduct; Digital Evidence Management; Collecting evidence; Antiforensics; Network forensics; Mobile and Embedded Forensics; Cloud forensics; Internet Forensics; social media forensics; Investigation Methods for Collecting Digital Evidence; Digital Forensic Readiness; Digital forensics tools; Discovery of Computers and Storage Media; Discovery of Audio/ Video Evidence; Data Visualization; Data Sources; Graphing and Charting; Analyzing Data; Data Distributions; Analysis Scenarios; Data Visualization Tools.

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

1. The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics by John Sammons, 2nd Edition or latest
2. Digital Forensics and Incident Response: Incident Response Techniques and Procedures to Respond to Modern Cyber Threats, 2nd Edition
3. Guide to Digital Forensics: A Concise and Practical Introduction by Joakim Kävrestad (latest edition).

Course Name:	**Digital Image Processing**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Calculus and Analytical Geometry, Linear Algebra, Artificial Intelligence
Course Introduction:	This is an introductory course in digital image processing. The course covers preliminary topics in DIP with emphasis on the mathematics for image processing and enhancement, filtering, segmentation, and restoration issues image processing. The aim is to enable students gain familiarity with digital image processing

problems, techniques, and methods.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understanding of the issues involved in image processing and the approaches, algorithms, and tools used to solve them.	C2 (Understand)
CLO-2	Able to compare and evaluate different approaches, and think about alternate solutions.	C4 (Analyze) & C5 (Evaluate)
CLO-3	Apply existing techniques to practical problems and undertake an undergrad level project in the area of image processing.	C3 (Apply)

Course Outline:

Introduction to Digital Image Processing (DIP). Fundamentals of Digital Image: visual perception, light and the electromagnetic spectrum, sensing and acquisition, sampling and quantization, basic relationships between pixels, mathematical tools for digital image processing, Transformation and spatial filtering in spatial and frequency domain: smoothing and filtering, combining spatial enhancement methods, selective filtering. Image restoration and reconstruction: restoration by spatial and frequency domain filtering, linear position invariant degradations, estimation of the degradation function, Wiener, least-squares, and mean filters, image reconstruction from projections. Image segmentation: point, line, and edge detection, thresholding, region-based segmentation, and the use of motion in segmentation.

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

1. Gonzalez, Rafael C. Digital image processing. 4th Edition, Pearson Education India, 2017.
2. Gonzalez, Rafael C. Digital image processing using MATLAB. 3rd Edition, Gatesmark, 2020.
3. Efford, Nick. Digital Image Processing: A Practical Introduction using Java (with CD- ROM). Addison-Wesley Longman Publishing Co., Inc., 2000.

Course Name:	**Graph Theory and Its Applications**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 3 Hours, Practical: 3 Hours
Pre-requisites:	Data Structures
Course Introduction:	This course provides an in-depth exploration of graph theory, covering fundamental concepts and their applications in computer science and other fields. Students will learn about various types of graphs, graph algorithms, and real-world applications. The course includes both theoretical lectures and practical lab sessions to reinforce learning.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamental concepts of graph theory.	C2 (Understand)
CLO-2	Understand different types of graphs and their properties.	C2 (Understand)
CLO-3	Implement graph algorithms to solve real-world problems.	C3 (Apply)
CLO-4	Apply graph theory concepts to various applications in computer science.	C3 (Apply)

Course Outline:

Introduction to Graph Theory: Definitions, terminology, and basic concepts such as vertices, edges, paths,

and cycles. Types of Graphs: Directed and undirected graphs, weighted graphs, bipartite graphs. Graph Properties: Connectivity, components, Eulerian and Hamiltonian paths, and circuits. Graph Algorithms – Searching: Depth-First Search (DFS) and Breadth-First Search (BFS). Graph Algorithms - Shortest Path: Dijkstra's and Bellman-Ford algorithms. Graph Algorithms - Minimum Spanning Trees: Kruskal's and Prim's algorithms. Graph Coloring: Vertex and edge coloring, chromatic number, applications. Network Flows: Max flow-min cut theorem, Ford-Fulkerson algorithm. Planar Graphs: Euler's formula, Kuratowski's theorem, applications. Graph Theory Applications: Applications in computer networks, social networks, biological networks. Lab Works: Creating graphs using Graph theory tools and software (e.g., Graphviz, NetworkX). Implementing DFS, BFS, Shortest Path, Spanning Tree, and Network Flow algorithms. Visualizing and testing properties of planar graphs.

Reference Materials:

1. Graph Theory and Its Applications by Jonathan L. Gross and Jay Yellen
2. Introduction to Graph Theory by Douglas B. West
3. Graph Theory by Reinhard Diestel
4. Discrete Mathematics and Its Applications by Kenneth H. Rosen
5. Graph Algorithms by Shimon Even

Course Name:	**Introduction to Cyber Security**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Information Security
Course Introduction:	This course provides students 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 Taxonomy
CLO-1	To be able to identify computer system threats	C2 (Understand)
CLO-2	To be able to identify Malware attacks, and understand the stages of attack and payloads.	C2 (Understand)
CLO-3	Implement various cryptographic techniques and simulate attack scenarios	C3 (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 Materials (or use any other standard and latest books):

1. Computer Security Fundamentals by Chuck Easttom, 4th edition or latest

2. Security+ Guide to Network Security Fundamentals, by Mark Ciampa, 5th Edition
3. Security in Computing by C.P. Pfleeger, Prentice-Hall, 4th Edition or Latest Book

Course Name:	**Introduction to Data Mining**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Introduction to Data Science
Course Introduction:	The main purpose of this course is the ability to analyze and construct knowledge from data. It aims to expand on the student's understanding and awareness of the concepts of data mining basics, techniques, and application. It introduces data pre-processing, summary statistics, frequent item set generation, association and correlation measures, classification, prediction, and clustering. It builds on the programming and problem-solving skills developed in previous subjects studied by the student, to achieve an understanding of the development of classification, prediction, and clustering applications.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Select and apply proper data mining algorithms to discover interesting patterns.	C3 (Apply)
CLO-2	Apply preprocessing techniques on any given raw data.	C3 (Apply)
CLO-3	Analyze and extract patterns to solve problems and point out how to deploy solution.	C4 (Analyze)
CLO-4	Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy.	C4 (Analyze)

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

1. Jiawei Han & Micheline Kamber, Jian Pei (2011). Data Mining: Concepts and Techniques, 3rd Edition.
2. Pang-Ning Tan, Michael Steinbach, and Vipin Kumar (2005). Introduction to Data Mining.
3. Charu C. Aggarwal (2015). Data Mining: The Textbook.
4. D. Hand, H. Mannila, P. Smyth (2001). Principles of Data Mining. MIT Press Horton.

Course Name:	**Introduction to Data Science**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Artificial Intelligence
Course Introduction:	Data Science is the study of the generalizable extraction of knowledge from data. Being a data scientist requires an integrated skill set spanning mathematics, statistics, machine learning, databases and other branches of computer science along with a good understanding of the craft of problem formulation to engineer effective solutions. The aim of this course is to: Introduce students to this rapidly growing field and equip them with some of its basic principles and tools as well as its general mindset. Explain the significance of exploratory data analysis in data science. Identify common approaches used for Feature Generation as well as Feature Selection, and finally discuss the Ethical and Privacy issues. Programming language Python has been proposed for the practical work of this course.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Describe what Data Science is and the skill sets needed to be a data scientist.	C2 (Understand)
CLO-2	Apply EDA and the Data Science process in a case study.	C3 (Apply)
CLO-3	Comprehend the fundamental constructs of Python programming language.	C2 (Understand)
CLO-4	Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C3 (Apply)

Course Outline:

Introduction: What is Data Science? Big Data and Data Science hype, Datafication, Current landscape of perspectives, Skill sets needed. Statistical Inference: Populations and samples, Statistical modeling, probability distributions, fitting a model, Intro to Python; Exploratory Data Analysis and the Data Science Process. Basic Machine Learning Algorithms: Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes; Feature Generation and Feature Selection. Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis. Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs. Data Visualization: Basic principles, ideas and tools for data visualization. Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists.

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

1. Foundations of data science, Blum, A., Hopcroft, J., & Kannan, R., Vorabversion eines Lehrbuchs, 2016.
2. An Introduction to Data Science, Jeffrey S. Saltz, Jeffrey M. Stanton, SAGE Publications, 2017.
3. Python for everybody: Exploring data using Python 3, Severance, C.R., CreateSpace Independent Pub Platform. 2016.
4. Doing Data Science, Straight Talk from the Frontline, Cathy O'Neil and Rachel Schutt, O'Reilly. 2014.
5. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2015.

Course Name:	**Machine Learning**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Artificial Intelligence
Course Introduction:	Machine learning is one of the fastest growing areas of computer science, with far-reaching applications. The aim of this course is to: a) Present the basic machine learning concepts; b) Present a range of machine learning algorithms along with their strengths and weaknesses; c) Apply machine learning algorithms to solve problems of moderate complexity.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Describe basic machine learning concepts, theories and applications.	C1 (Knowledge)
CLO-2	Apply supervised learning techniques to solve classification problems of moderate complexity.	C3 (Apply)
CLO-3	Apply unsupervised learning techniques to solve clustering problems of moderate complexity.	C3 (Apply)
CLO-4	Apply reinforcement-learning algorithms to environments with complex dynamics.	C3 (Apply)
CLO-5	Develop a reasonable size project using suitable machine learning technique.	C6 (Create)

Course Outline:

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

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

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

Course Name:	**Mobile Application Development – I**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Advanced Programming
Course Introduction:	This course introduces mobile applications programming. The goal of this course is to teach and train students how to design, implement, test, debug and publish smartphone applications on smartphone platforms, especially Android. Students will learn how to take their innovative ideas from conception to the apps market through a series of rigorous hands-on programming assignments and group projects. This is an introductory course aimed at undergraduate students, who have object-oriented

programming experience. However, there is a significant amount of programming in this course requiring a commitment on the part of the student. A key part of this course is group projects where students will work in small teams for joint problem solving.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand aspects of mobile applications programming and uniqueness from programming for other platforms.	C2 (Understand) & C4 (Analyze)
CLO-2	Understand mobile applications development for the Android operating system that use basic and advanced phone features.	C3 (Apply)
CLO-3	Design, implement, test, debug and publish smartphone applications.	C3 (Apply)
CLO-4	Create innovative and robust mobile applications that will be valuable addition to their programming portfolio.	C6 (Create)

Course Outline:

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

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

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

Course Name: **Mobile Application Development – II**

Credit Hours: 3 (2-3)

Contact Hours: Theory: 2 Hours, Practical: 3 Hours

Pre-requisites: Mobile Application Development – I

Course Introduction: This course is a continuation of Mobile Application Development – I. In this course, students will learn about cross-platform (iOS and Android) mobile applications development using the Flutter framework and Dart language. The lecture session covers detailed concepts whereas the lab sessions give you a hands-on experience on the topics covered in the lecture sessions

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of the Flutter framework and Dart language, incorporate widgets and state into mobile applications, and use Flutter's tools to enhance development process.	C2 (Understand)
CLO-2	Apply the principles, and methods of cross-platform tools to develop interactive mobile applications.	C3 (Apply)
CLO-3	Test cross-platform mobile applications	C5 (Evaluate)

Course Outline:

Setting Flutter Development Environment. Flutter UI: Important Widgets, themes and layout. User Interactions: Forms and Gestures, Flutter Animations and Using Canvas, Flutter Routing, Flutter State Management. Dart Object-Oriented Programming Concepts (Keywords, built-in types, functions, operators, control flow statements, exceptions, classes, generics, libraries and visibility, asynchrony support, generators, callable classes, isolates, typedefs, metadata, comments). Working with Files (Reading/Writing to Files, Using JSON, Using Shared Preferences). Working with SQLite Database. Making RESTful APL Calls with HTTP. Using Firebase. Working with Location and Maps. Testing Flutter Applications.

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

1. Alessandria, Simone, and Brian Kayfitz. Flutter Cookbook: Over 100 proven techniques and solutions for app development with Flutter 2.2 and Dart. Packt Publishing Ltd, 2021.
2. Bailey, Thomas, and Alessandro Biessek. Flutter for Beginners: An introductory guide to building cross-platform mobile applications with Flutter 2.5 and Dart. Packt Publishing Ltd, 2021.
3. Chopra, Deepti, and Roopal Khurana. Flutter and Dart: Up and Running: Build native apps for both iOS and Android using a single codebase (English Edition). BPB Publications, 2023.

Course Name:	**Natural Language Processing**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Artificial Intelligence
Course Introduction:	Natural Language Processing (NLP) is the application of computational techniques to the analysis and synthesis of natural language and speech. This course is an introduction to NLP with prior programming experience in Python.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand techniques for information retrieval, language translation, and text classification.	C2 (Understand)
CLO-2	Understand the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks.	C2 (Understand)
CLO-3	Understand and contrast deterministic and stochastic grammar, providing examples to show the adequacy of each.	C2 (Understand)
CLO-4	Solve classic and stochastic algorithms for parsing natural language.	C2 (Apply)

Course Outline:

Introduction & History of NLP, Parsing algorithms, Basic Text Processing, Minimum Edit Distance, Language Modeling, Spelling Correction, Text Classification, Deterministic and stochastic grammars, CFGs, Representing meaning /Semantics, Semantic roles, Semantics and Vector models, Sentiment Analysis, Temporal representations, Corpus-based methods, N-grams and HMMs, Smoothing and backoff, POS tagging and morphology, Information retrieval, Vector space model, Precision and recall, Information extraction, Relation Extraction (dependency, constituency grammar), Language translation, Text classification, categorization, Bag of words model, Question and Answering, Text Summarization

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

1. Daniel Jurafsky and James H. Martin. 2018. Speech and Language Processing: An Introduction to Natural Language Processing. Third Edition. Prentice Hall.

2. Foundations of Statistical Natural Language Processing, Manning and Schütze, MIT Press. Cambridge, MA: May 1999.

Course Name:	**Object-Oriented Analysis & Design**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Object Oriented Programming
Course Introduction:	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 Outcomes	Bloom Taxonomy
CLO-1	To learn aspects of Object-oriented analysis and design.	C2 (Understand)
CLO-2	To be able to analyze complex computing/ real world problems using object-oriented principles.	C4 (Analyze)
CLO-3	To be able to design computing/real world problems as object-oriented problems using object-oriented techniques.	C6 (Create)

Course Outline:

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

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

1. Larman, Craig. Applying UML and Patterns: An Introduction to Object Oriented Analysis and Design and Interative 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.
6. Booch, G, Rambaugh, J and Jakobson, I. The Unified Modeling Language User Guide. Addison-Wesley Professional; 2nd Edition (2005).

Course Name:	**Semantic Web**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Programming Fundamentals, Web Technologies
Course Introduction:	This course introduces the key concepts of the Internet, World Wide Web, and web technologies with practically practicing HTML, JavaScript, and PHP. It then covers the various aspects of Semantic Web and its enabling technologies, including ontologies, RDF, RDFS, and OWL.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of Internet, World Wide Web, and Web Technologies.	C2 (Understand)
CLO-2	Understand Semantic Web, ontologies, RDF, RDFs, and OWL.	C2 (Understand)
CLO-3	Practice HTML, JavaScript, PHP, and working with Web Protégé.	C3 (Apply)

Course Outline:

Fundamentals: Internet, The World Wide Web, Web Browsers, Web Servers, Uniform Resource Locators, Web development tools and IDEs. HTML5: Basic Syntax, Basic Text Markup, Images, Hypertext Links, Lists, Tables, Forms. Basics of Cascading Style Sheets. Basics of JavaScript and Hypertext Preprocessor (PHP). Database Access with PHP and MySQL. The Semantic Web, Syntactic and Semantic Web, Semantic Web Applications, Ontology in Computer Science, Resource Description Framework (RDF), RDF Schema, OWL, and Linked Open Data.

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

1. Programming the World Wide Web by Robert W. Sebesta, 8th edition.
2. JavaScript: The Definitive Guide7th Edition by David Flanagan.
3. PHP & MySQL: Server-side Web Development by Jon Ducket.
4. Foundations of Semantic Web Technologies (Chapman & Hall/CRC Textbooks in Computing) 1st Edition by Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph.

Course Name:	**Software Project Management**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Software Engineering
Course Introduction:	This course introduces students to the principles and practices of managing software projects. It covers the entire project lifecycle, from initiation to closure, and emphasizes the application of project management tools and techniques to ensure successful project delivery.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of software project management.	C2 (Understand)
CLO-2	Apply project management methodologies to plan, execute, and control software projects.	C3 (Apply)

CLO-3	Develop project plans that include tasks, timelines, and resource allocation.	C3 (Apply)

Course Outline:

Key concepts and terminologies of Software Project Management. Phases of the project life cycle. Overview of project management methodologies (Agile, Waterfall, Scrum). Project Initiation: Project selection and prioritization. Defining project scope and objectives. Project Planning: Developing a project plan. Work breakdown structure (WBS). Scheduling and Time Management: Creating project schedules. Gantt charts and PERT diagrams. Resource Management: Resource allocation and leveling. Team building and leadership. Cost Management: Budgeting and cost estimation. Cost control techniques. Quality Management: Defining quality standards. Quality assurance and quality control. Risk Management: Identifying project risks. Risk mitigation strategies. Communication Management: Stakeholder communication. Communication plan development. Procurement Management: Procurement planning and contracts. Vendor selection and management. Project Execution: Monitoring and controlling project progress. Managing project teams. Change Management: Handling change requests. Change control processes. Project Closure: Project handover and documentation. Post-project evaluation. Labs include creating a detailed project plan for a hypothetical software project, including tasks, timelines, and resource allocation, and handling its risks. Creating Gantt and PERT chars. Working with MS Project.

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

1. Software Project Management: A Unified Framework by Robert K. Wysocki – 2004
2. Managing Software Projects: A Practical Guide by Craig Larman – 1999
3. Software Engineering: A Practitioner's Approach by Roger S. Pressman – 2020
4. The Software Project Manager's Answer Book by Linda Hayes, Robin Goldsmith, and Wanda Curlee – 2005
5. Project Management: A Systems Approach to Planning, Scheduling, and Controlling" by Harold R. Kerzner – 2017

Course Name:	**Software Testing and Quality Assurance**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Software Engineering
Course Introduction:	This course offers a comprehensive introduction to the principles, methodologies, and practices of software testing and quality assurance. Students will learn about various testing techniques, quality models, and the role of testing in the software development lifecycle (SDLC). The course also covers the latest trends and tools in software testing, preparing students to ensure the quality and reliability of software systems.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamental concepts of software testing and quality assurance.	C2 (Understand)
CLO-2	Explain the different types of software testing and their purposes.	C2 (Understand)
CLO-3	Apply appropriate testing techniques to various stages of the software development lifecycle.	C3 (Apply)

Course Outline:

Overview of software testing, importance, and objectives. Basic concepts, types of testing, and testing

terminology. Phases of Software Testing Life Cycle (STLC), entry and exit criteria, and test planning. Black-box testing, white-box testing, and grey-box testing. Writing effective test cases, and test case management tools. Test execution process, defect logging, and tracking. Static testing techniques, code reviews, and walkthroughs. Dynamic testing techniques, introduction to test automation tools. Load testing, stress testing, and performance tuning. Security vulnerabilities, penetration testing, and ethical hacking. Usability principles, user experience testing, and accessibility testing. Quality models (ISO 9126, CMMI), quality metrics, and measurement. Software Quality Assurance (SQA), SQA processes, SQA activities, and SQA tools. The practical aspects cover working with testing tools (e.g., Selenium and JUnit), performance testing tools (e.g., JMeter), and defect management tools (e.g., Bugzilla, JIRA).

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

1. Software Testing: A Craftsman's Approach by Paul C. Jorgensen – 2008
2. Lessons Learned in Software Testing: A Context-Driven Approach by Cem Kaner, James Bach, and Bret Pettichord – 2001
3. Software Testing: Principles and Practices by Rex Black – 2006
4. How Google Tests Software by James Whittaker, Jason Arbon, and Jeff Carollo – 2012
5. Software Quality Assurance: Theory and Practice by Kshirasagar Naik and Priyadarshi Tripathy – 2010
6. Software Quality Assurance: Integrating Testing, Security, and Audit by Mahfuz Ahmed – 2021

Course Name:	**Web Engineering**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Web Technologies, Software Engineering
Course Introduction:	The World Wide Web has become a major delivery platform for information resources. Many applications continue to be developed in an ad-hoc way, contributing to problems of usability, maintainability, quality and reliability. Web Engineering introduces a structured methodology used in software engineering for web development projects.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the concepts, principles and methods of Web Engineering.	C2(Understand)
CLO-2	Apply the Web Engineering concepts, methods, principles, and methodologies to ensure an operable, usable, maintainable, and secure web application	C3(Apply)

Course Outline:

Categories of Web Applications, Product-, Usage-, and Development-related Characteristics of Web Applications. Technologies for Web Application Development: Client/Server Communication on the Web (SMTP, RTSP, HTTP), Client-side Technologies, Document-specific Technologies (HTML, SVG, SMIL, XML), Server-side Technologies (URI Handlers, Web Services, Middleware Technologies). Requirements Engineering Activities of Web Applications, Adapting Requirements Engineering Methods to Web Application Development. Modelling Specifics in Web Engineering (Requirements, Content, Hypertext, Presentation, and Customization). Design Guidelines. Web Usability Engineering Methods, and Trends. Web Application Development Process: Parallel Development of Different Releases, Analysis of the Rational Unified Process, Analysis of Extreme Programming. Web Project Management: Challenges in Web Project Management, Managing Web Teams, Managing the Development Process of a

Web Application.

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

1. Chopra, R. (2016). Web Engineering (Latest Edition). PHI Learning Pvt. Ltd.
2. Suh, W. Web Engineering Principles and Techniques (Latest Edition). Idea Group Publishing.
3. Pressman, R., & Lowe, D. Web Engineering: A Practitioners Approach (Latest Edition). McGraw-Hill.

Course Name:	**Web Technologies**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	Programming Fundamentals
Course Introduction:	Introduces the web technologies necessary for the theory and practice of developing web pages and web applications. The main focus is on enabling students to grasp the key concepts of Internet and the Web, learn markup and scripting languages to develop web pages. The course includes hands-on labs to practice markup and styling web pages and writing scripts for client and server sides of the Web.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of Internet, World Wide Web, and Web Technologies.	C2 (Understand)
CLO-2	Understand the syntax of markup and scripting languages necessary for programming the Web	C2 (Understand)
CLO-3	Apply the markup and scripting languages in creating web pages.	C3 (Apply)

Course Outline:

Fundamentals: Internet, The World Wide Web, Web Browsers, Web Servers, Uniform Resource Locators, Multipurpose Internet Mail Extensions, The Hypertext Transfer Protocol, Web development tools and IDEs. HTML5: Basic Syntax, Standard HTML Document Structure, Basic Text Markup, Images, Hypertext Links, Lists, Tables, Forms. Cascading Style Sheets: Levels of Style Sheets, Style Specification Formats, Selector Forms, Property-Value Forms, Font Properties, List Properties, Alignment of Text, Color, The Box Model, Background Images, The and Tags, Conflict Resolution. JavaScript: General Syntactic Characteristics, Primitives, Operations, and Expressions, Screen Output and Keyboard Input, Control Statements, Object Creation and Modification, Arrays, Functions, Constructors, Pattern Matching Using Regular Expressions. Hypertext Preprocessor (PHP): General Syntactic Characteristics, Primitives, Operations, and Expressions, Control Statements, Arrays, Functions, Pattern Matching, Form Handling, Cookies, Session Tracking. The Basics of AJAX. Database Access through the Web: Relational Databases, Structured Query Language, Architectures for Database Access, The MySQL Database System, Database Access with PHP and MySQL.

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

7. Programming the World Wide Web by Robert W. Sebesta, 8th edition
8. JavaScript: The Definitive Guide7th Edition by David Flanagan
9. PHP & MySQL: Server-side Web Development by Jon Ducket

2.4. Interdisciplinary/Allied (Mathematics & Supporting) Courses

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the key concepts of Linear Algebra.	C2 (Understand)
CLO-2	Understand the applications of Linear Algebra in Computer Science, including, e.g., Search Engines, Information Retrieval, etc.	C2 (Understand)

Course Outline:

Algebra of linear transformations and matrices. determinants, rank, systems of equations, vector spaces, orthogonal transformations, linear dependence, linear Independence and bases, eigenvalues and eigenvectors, characteristic equations, Inner product space and quadratic forms.

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

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

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Measures of central tendency and variation.	C1 (Remember)
CLO-2	The concept of sets, probability, random variables, and probability distribution.	C2 (Understand)
CLO-3	Statistical inference, regression, and correlation	C4 (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, FQuantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of PValues for Decision Making in Testing Hypotheses (Single Sample & One- and TwoSample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

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

1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, Pearson; 9th Edition (January 6, 2011). ISBN-10: 0321629116
2. Probability and Statistics for Engineers and Scientists by Anthony J. Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10:0495107573
3. Schaum's Outline of Probability and Statistics, by John Schiller, R. Alu Srinivasan and Murray Spiegel, McGraw-Hill; 3rd Edition (2008). ISBN-10:0071544259.

Course Name:	**Multivariate Calculus**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	Calculus and Analytical Geometry
Course Introduction:	This course is an extension of single-variable calculus. It focuses on calculus as it applies to functions of two or more variables. The concept learnt in this course will be useful in analyzing the geometry of curves and surfaces.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the basic concepts of multivariable calculus.	C2 (Understand)
CLO-2	Understand concepts as parametric curves, matrix algebra, gradients, directional derivatives, and multiple integrals.	C5 (Evaluate)
CLO-3	Physical interpretation of these concepts and application in constrained-unconstrained optimization	C4 (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 Materials (or use any other standard and latest books):

1. Stewart, J., & Cole, B. (2015). Multivariable Calculus (8th Edition). Cengage Learning.
2. 2. Briggs, W. L., Cochran, L., & Gillett, B. (2014). Multivariable Calculus (2nd Edition). Pearson Education India.

Course Name:	**Technical & Business Writing**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	Students in 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 in order to sensitize them to the dynamics, challenges, and needs of the modern world characterized by technologically advanced social, cultural, and corporate settings. It will focus on students' ability to effectively convey and exchange information in cross-cultural, international, and multinational milieu necessitated by the emergence of global society.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand requirements of technical and academic writings in computer science.	C2 (Understand)
CLO-2	Have familiarity of different aspects of technical writing.	C3 (Apply)
CLO-3	Have improved technical writing skills.	C3 (Apply)
CLO-4	Have understanding of how to avoid informal language in academic writing	C4 (Differentiate)

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. Writing hypotheses, questions and evidence, Describing mathematics. Describing algorithms. Explaining graphs, figures, and tables. Discussing experimentation. Writing a paper. Creating effective presentations.

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

1. Zobel, J. (2009). Writing for Computer Science (2nd Edition). Springer.
2. Hardesty, R. E. (2010). Technical and Business Writing for Working Professionals (Latest Edition). Xlibris Corporation.
3. Brown, B. W. (1993). Successful Technical Writing/Instructor's Guide (Latest Edition). Goodheart-Willcox Publisher.

2.5. Field Experience

Course Name:	**Field Experience/Internship**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	Field experience/Internship of 6-8 weeks during the winter semester graded by a faculty member in collaboration with the field supervisor.

CLO No.	Course Learning Outcomes	Bloom Taxonomy

Course Outline:

The field experience of six to eight weeks (preferably undertaken during the semester or winter break) must be graded by a faculty member in collaboration with the supervisor in the field. This is a mandatory degree award requirement of 3 credit hours for a BS Computer Science degree. Although the Internship is in the 5th Semester of the study plan, this is not mandatory. Students should complete Field Experience/Internship in Winter Breaks after the 4th Semester and before the conclusion of the 7th Semester. Students completing Field Experience/Internship in this specified duration will not be marked as repeaters in their BS Transcript.

Reference Materials:

1. Careers in Computer Science and Programming (Careers in Computer Technology), 2011 by Jeri Freedman
2. The Career Counselor's Handbook, Second Edition by Howard Figler Richard N. Bolles
3. Computer Science, Why study it and Best Jobs in computer science (English Edition) by E King

2.6. Elective Supporting Courses

Course Name:	**Introduction to Marketing**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course introduces the foundations and key concepts of marketing as they relate to the whole business enterprise. It provides an understanding of marketing in relation to the product and services including the planning process, organizing the marketing functions, and implementing the marketing decisions keeping in mind the ethical, legal and societal considerations.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand marketing concepts, its elements, the marketplace, marketing communication, and the consumers.	-
CLO-2	Understand the elements in the marketing mix and their application in marketing decisions.	-

CLO-3	Understand the importance of customer relationships in marketing and the creation of customer value.	-
CLO-4	Discuss social responsibility and ethics in marketing.	-

Course Outline:

Marketing: marketing and the society, definition, importance, and scope of marketing. Marketing environments: the marketing environment, macro and microenvironments. Marketing and strategy: strategic planning, strategic marketing planning, and forecasting marketing demand. Marketing decisions: information required for marketing decisions and marketing research. Consumer behavior: information for purchase decisions, consumer decision process, influence of social and psychological factors, and market implications. Market segmentation and targeting: factors for segmentation, selecting the target market, developing the positioning and target market strategies. Products and services: Definition of product and services, classification of consumer goods, and classification of business goods. Pricing, its importance, and factors affecting pricing decisions. Advertisement and publicity: Scope and characteristics of advertisement and publicity, Development, planning and implementation of advertising plan, Evaluating the success and failure of promotional plan. Marketing strategies for e-Business and e-Commerce.

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

1. Philip Kotler, Principles of Marketing (Latest Edition)
2. David Jobber, Principles of Marketing (Latest Edition)
3. Jerome McCarthy & William, D. Pareanth, Basics Marketing, (Latest Edition).

2.7. General Education Courses

Course Name:	**Applications of Information and Communication Technologies (ICT)**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	This course is introduced to provide students with a practical understanding of how information and communication technologies (ICT) are used in various fields and industries. The course covers such areas of knowledge within the application of ICT tools, software, and systems to enhance productivity, communication, decision-making, and problem-solving across different domains. Through this course, students will be engaged in hands-on activities, projects and assignments to reinforce their understanding of ICT applications. The objective of the course is to build an appreciation for the fundamental concepts in computing and to become familiar with popular PC productivity software.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the basics of computing technology	C1 (Knowledge)
CLO-2	Do number systems conversions and arithmetic	C2(Understand)
CLO-3	Know the types of software	C2(Understand)
CLO-3	Know computing-related technologies	C3 (Apply)

Course Outline:

A Brief History and Generations of Computers. Types of Computer (Super, Mainframe, Mini, and Micro Computer). Computer Elements: Hardware (Central Processing Unit. Memory: Random Access Memory and Its Types, Read-Only Memory, Cache. Storage Devices: Hard Drive, Solid State Drive, Diskettes,

RAID, Optical Disk Storages (DVD, CD ROM), Magnetic Types, Backup System. Motherboard. Power Supply Unit. Input Devices: Keyboard and Its Types, Pointing Devices (Mouse), Voice Input, and Scanners. Output Devices: Monitor and Its Types, Printer and Its Types, Plotters, and Terminals (Dump, Smart, Intelligent). Graphics Processing Unit). Software (System Software, Its Importance and Types: Operating System, Drivers, Firmware, and Utilities. Application Software and Its Uses & Limitations). Network Components (Data Communications, Data Communication Model, Data Transmission, Digital and Analog Transmission, Modems, Routers, Asynchronous and Synchronous Transmission, Simplex. Half-Duplex, Full Duplex Transmission, Media (Cables, Wireless), Protocols, Network Topologies (Star, Bus, Ring), LAN, MAN, WAN). Peripherals (External Storage: USB drives, external hard drives, etc. Peripheral Devices: Printers, scanners, webcams, etc.). Computer-Based Information System. Organizing Computer Facility: Centralized, Distributed, and Decentralized Computing Facilities. Dedicated Data Entry. Source Data Automation. Soft and Hard Copies. Computer Virus and its Forms. Internet and World Wide Web: A Brief History, Birthplace of ARPA Net, Web Link, Browser, Internet and Online Services Providers, Function and Features of Browser, Search Engines, Some Common Services available on Internet.

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

1. Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA, 2016
2. Sinha, Pradeep K., and Priti Sinha. Computer fundamentals. BPB publications, 2010.

Course Name:	**Functional English**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course is designed to equip students with essential language skills for effective language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced message and tailor their communication effectively through application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking, and everyday conversation, ensuring that students are equipped for both acidic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact on their functional interactions.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Apply enhanced English communication skills through effective use of word choice grammar and sentence structure.	C3 (Apply)
CLO-2	Comprehend a variety of literary / non-literary written and spoken texts in English.	C2 (Understand)
CLO-3	Effectively express information, ideas, and opinions in written and spoken English.	C3 (Apply)
CLO-4	Recognize inter-cultural variations in the use of English language to effectively adapt their communication style and	C4 (Analyze)

content based on diverse cultural and social contexts.

Course Outline:

The foundation of functional English: Vocabulary building (contextual usage, synonyms, antonyms, and idiomatic expressions). Communication grammar (subject-verb-agreement verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.). Word formation (affixation, compounding, clipping, back-formation, etc.). Sentence structure (simple, compound, complex, and compound-complex). Sound production and pronunciation. Comprehension and Analysis: Understanding purpose, audience, and context. Contextual interpretation (tones, biases stereotypes, assumptions, inferences, etc.). Reading strategies (skimming, scanning, SQ4R, critical reading, etc.). Active listening (overcoming listening barriers, focused listening, etc.). Effective Communication: Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.). Structure documents (instruction, body, conclusion, and formatting). Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.). Public speaking (overcoming stage fright, voice modulation, and body language). Presentation skills (organization of content, visual aids, and engaging the audience). Professional writing (business e-mail, memos, reports, formal letters, etc.).

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

1. Understanding and Using English Grammar by Betty Schrampfer Azar.
2. English Grammar in Use by Raymond Murphy.
3. The Blue Book of Grammar and Punctuation by Jane Straus.
4. English for Specific Purposes: A Learning –Centered Approach by Tom Hutchinson and Alan Waters.
5. Cambridge English for Job-hunting by Colm Downes.
6. Practical English Usage by Michael Swan.
7. Reading Literature and Writing Argument by Missy James and Alan P. Merickel.
8. Improving Reading: Strategies Resources and Common Core Connections by Jerry Johns and Susan Lenski.
9. Comprehension: A Paradigm for Cognition by Walter Kintsch.
10. Communication Skills for Business Professionals by J. P. Verma and Meenakshi Ramman.

Course Name:	**Calculus and Analytical Geometry (CAG)**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	To provide the foundation and basic ground for calculus and analytical geometry background.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	Understand the key concepts of calculus and analytical geometry	C2 (Understand)

Course Outline:

Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of finding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential

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

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

1. Calculus and Analytic Geometry by Kenneth W. Thomas.
2. Calculus by Stewart, James.
3. Calculus by Earl William Swokowski; Michael Olinick; Dennis Pence; Jeffery A. Co.

Course Name:	**Discrete Structures**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
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 an understanding and appreciation of the finite nature inherent in most Computer Science problems and structures through the study of combinatorial reasoning, abstract algebra, iterative procedures, predicate calculus, and 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 Taxonomy
CLO-1	Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.	C2 (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 such as puzzles.	C3 (Apply)
CLO-3	Apply discrete structures to other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C3 (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	C4 (Differentiate)

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

1. Discrete Mathematics and Its Applications, 7th edition by Kenneth H. Rosen

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

Course Name:	**Islamic Studies**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course is designed to provide students with a comprehensive overview of the fundamental aspects of Islam, its beliefs, practices, history, and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course, students will have an enhanced understanding of Islam's multifaceted dimensions, which will enable them to navigate complex discussions about Islam's historical and contemporary role, fostering empathy, respect, and informed dialogue.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Demonstrate enhanced knowledge of Islamic foundational beliefs, practices, historical development, spiritual values, and ethical principles.	-
CLO-2	Describe basic sources of Islamic law and their application in daily life.	-
CLO-3	Identify and discuss contemporary issues being faced by the Muslim world including social challenges, gender roles, and interfaith interactions.	-

Course Outline:

Introduction to Islam: Definition of Islam and its core beliefs. The Holy Quran (introduction, revelation, and compilation). Hadith and Sunnah (compilation, classification, and significance). Key theological concepts and themes (Tawhid, Prophethood, Akhirah, etc.). Seerah of the Holy Prophet (Peace Be Upon Him) as Uswa-i-Hasana: Life and legacy of the Holy Prophet PBUH. Diverse roles of the Holy Prophet PBUH (as an individual, educator, peacemaker, leader, etc.). Islamic History and Civilization: World before Islam. The Rashidun Caliphate and expansion of Islamic rule. Contribution of Muslim scientists and philosophers in shaping world civilization. Islamic Jurisprudence (Fiqh): Fundamental sources of Islamic jurisprudence. Pillars of Islam and their significance. Major schools of Islamic jurisprudence. Significance and principles of Ijtihad. Family and Society in Islam: Status and rights of women in Islamic teachings. Marriage, family, and gender roles in Muslim society. Family structure and values in Muslim society. Islam and the Modern World: Relevance of Islam in the modern world (globalization, challenges and prospects). Islamophobia, interfaith dialogue, and multiculturalism. Islamic viewpoint towards socio-cultural and technological changes.

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

1. The Five Pillars of Islam: A Journey through the Divine Acts of Worship by Muhonenad Mustafa Al-Asami.
2. The Five Pillars of Islam. A Framework for Islamic Values and Character Building by Musharraf Hussain.

3. Towards Understanding Islam by Abul Ata Mawdudi.
4. Islami Nazriya-e-Hayat by Khurshid Ahmad.
5. An Introduction to Islamic Theology by Jel Renard.
6. Women and Social Justice: An Istante Paradigm by Dr. Anis Ahmad.
7. Islam: Its Meaning and Message by Khurshid Ahmad.
8. Introduction to Islam by Dr. Hamidullah, Papular Library Publishers Lahore
9. Principles of Islamic Jurisprudence by Ahmad Hassan, Islamic Research Institute, IIUI
10. Muslim Jurisprudence and the Quranic Law of Crimes, By Mir Waliullah, Islamic Books Services.

***Note:** This course is compulsory for Muslim and optional for non-Muslim undergraduate students. Non-Muslim students can opt for any course of at least the same or more credits in subjects such as religious studies, ethics, theology, comparative religion, Christian ethics, etc.

Course Name:	**Ideology and Constitution of Pakistan**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.	-
CLO-2	Demonstrate fundamental knowledge about the constitution of Pakistan 1973 and its evolution with special reference to state structure.	-
CLO-3	Explain about the guiding principles on rights and responsibilities of Pakistan citizens as enshrined in the Constitution of Pakistan 1973.	-

Course Outline:

Introduction to the ideology of Pakistan: Definition and significance of ideology. Historical context of the creation of Pakistan (with emphasis on socio-political, religious, and cultural dynamics of British India between 1857 and 1947). Contributions of the founding fathers of Pakistan in the freedom movement, including Allama Muhammad Iqbal, Muhammad Ali Jinnah, etc. Contributions of women and students in the freedom movement for separate homeland for Muslims of British India. Two-Nation Theory: Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's presidential address 1930, Congress Ministries 1937 Lahore Resolution 1940). Role of communalism and religious differences. Introduction to the Constitution of Pakistan: Definition and importance of a constitution. Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949). Overview of constitutional development in Pakistan. Constitution and State Structure: Structure of Government (executive, legislature, and judiciary). Distribution of powers between federal

and provincial governments. 18th Amendment and its impact on federalism. Fundamental Rights, Principles of Policy and Responsibilities: Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28). Overview of principles of policy (Articles 29-40). Responsibilities of the Pakistan citizens (Article 5). Constitutional amendments: Procedures for amending the Constitution. Notable constitutional amendments and their implications.

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

1. The Idea of Pakistan by Stephen P. Cohen.
2. Ideology of Pakistan by Javed Iqbal.
3. The Struggle for Pakistan by I.H. Qureshi.
4. Pakistan the Formative Phase by Khalid Bin Sayeed.
5. Pakistan: Political Roots and Development by Safdar Mahmood.
6. Ideology of Pakistan by Sharif-ul-Mujahid.
7. The Struggle for Pakistan: A Muslim Homeland and Global Politics by Ayesha Jalal.
8. Jinnah, Pakistan, and Islamic Identity: The Search for Saladin by Akbar S. Ahmed.
9. The Making of Pakistan: A Study in Nationalism by K.K. Aziz
10. Pakistan: A New History by Ian Talbot.
11. Pakistan in the Twentieth Century: A Political History by Lawrence Ziring.
12. The Constitution of Pakistan 1973. Original.
13. Constitutional and Political Development of Pakistan by Hamid Khan.
14. The Parliament of Pakistan by Mahboob Hussain.
15. Constitutional Development in Pakistan by G.W. Choudhury.
16. Constitution-Making in Pakistan: The Dynamics of Political Order by G.W. Choudhury.

Course Name:	**Applied Physics (Natural Sciences)**
Credit Hours:	3 (2-3)
Contact Hours:	Theory: 2 Hours, Practical: 3 Hours
Pre-requisites:	None
Course Introduction:	The course introduces students to the basic concepts 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 Taxonomy
CLO-1	Comprehend the working knowledge of fundamental laws of physics.	C2(Understand)
CLO-2	Apply the knowledge of fundamental laws to solve various real world problems.	C3(Apply)
CLO-2	Analyze different physical problems using the knowledge gained from different areas like electromagnetism, optics etc.	C4(Analyze)

Course Outline:

Electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charge isolated conductor, Electric potential energy, Electric potentials, Calculating the potential from the field and related problem

Potential due to point and continuous charge distribution, Potential due to dipole, equipotential surfaces, Calculating the field from the potential, Electric current, Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot-Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroids, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf, Induced electric field, Induced electric fields, The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.

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

1. Fundamentals of Physics (Extended), 10th edition, Resnick and Walker
2. Narciso Garcia, Arthur Damask, Steven Schwarz., "Physics for Computer Science Students", Springer Verlag, 1998.

Course Name:	**Pakistan Studies**
Credit Hours:	Non-credit course (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course is designed to provide students with a comprehensive explanation of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. This course aims to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.	-
CLO-2	Understand the society and culture of Pakistan.	-
CLO-3	Understand and explain the socio-economic developments in Pakistan.	-
CLO-4	Explore contemporary issues and challenges faced by Pakistan and their implications for the future.	-

Course Outline:

Introduction to Pakistan: Geographical location and significance. Historical background: Ancient civilizations in the region. Factors leading to the creation of Pakistan. Political History of Pakistan: Formative phase. Military interventions and democratic transitions. Geography of Pakistan: Physiography: Mountains, plains, plateaus, valleys, and coastal areas. River system: Indus River and its tributaries. Climatic regions of Pakistan. Society and Culture of Pakistan: Socio-cultural diversity. Languages and literature of Pakistan. Economic Development of Pakistan: Agriculture and industrial sectors of Pakistan. Economic challenges of Pakistan. Contemporary issues: Foreign relations of Pakistan. Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

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

1. Jinnah of Pakistan by Stanley Wolpert
2. The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan by Ayesha Jalal
3. The Struggle for Pakistan by Ishtiaq Husain Qureshi
4. Pakistan, the Formative Phase, 1857-1948 by Khalid B. Sayeed
5. Pakistan Studies: A Book of Readings by Sikandar Hayat
6. Constitutional and Political History of Pakistan by Hamid Khan
7. Trek to Pakistan by Ahmad Saeed and Kh. Mansur Sarwar
8. Pakistan: A Modern History by Ian Talbot
9. Politics in Pakistan: The Nature and Direction of Change by Khalid B.Sayeed
10. Physical Geography of Pakistan by Umar Jahangir
11. A Geography of Pakistan: Environment, People, and Economy by Fazle Karim Khan
12. Pakistan's Foreign Policy: An Historical Analysis by S. M. Burke
13. Separatism in East Pakistan by Rizwan Ullah Kokab
14. Being Pakistani: Society, Culture and the Arts by Raza Rumi
15. Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects edited by Abdul Jabbar Khan
16. Language and Politics in Pakistan by Tariq Rahman
17. Sociology by Horton and Hunt
18. Pakistan in the Twentieth Century: A Political History by Lawrence Ziring
19. Economic Development of Pakistan by Ishrat Husain
20. Issues in Pakistan's Economy by S. Zaidi

Course Name:	**Expository Writing**
Credit Hours:	3 (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	Functional English
Course Introduction:	Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation of the pre-requisite course, Functional English, this course will enhance students' abilities to produce clear, concise, and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information, and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	Understand the essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.	-
CLO-2	Demonstrate mastery of diverse expository types to address different purposes and audiences.	-
CLO-3	Uphold ethical practices to maintain originality in expository in expository writing.	-

Course Outline:
Introduction to Expository Writing: Understanding expository writing (definition, types, purpose, and applications). Characteristics of effective expository writing (clarity, coherence, and organization). Introduction to paragraph writing. The Writing Process: Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining, etc.). Drafting (three-stage process of drafting techniques). Revising and editing (ensuring correct grammar, clarity, coherence, conciseness, etc.). Proofreading (fine-tuning of the draft). Peer review and feedback (providing and receiving critique). Essay Organization and Structure: Introduction and hook (engaging readers and introducing the topic). Thesis statement (crafting a clear and focused central idea). Body Paragraphs (topic sentences, supporting evidence, and transitional devices). Conclusion (types of concluding paragraphs and leaving an impact). Ensuring cohesion and coherence (creating seamless connections between paragraphs). Different Types of Expository Writing: Description. Illustration. Classification. Cause and effect (exploring causal relationship and outcomes). Process analysis (analyzing similarities and differences). Comparative analysis (analyzing similarities and differences). Writing for Specific Purposes and Audiences: Different types of purposes (to inform, to analyze, to persuade, to entertain, etc.). Writing for academic audiences (formality objectivity, and academic conventions). Writing for public audiences (engaging, informative, and persuasive language). Different tones and styles for specific purposes and audiences.

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

1. The St. Martin's Guide to Writing by Rise B. Axelrod and Charles R Cooper.
2. They Say / I Say: The Moves That Matter in Academic Writing by Gerald Graff and Cathy Birkenstein.
3. Writing Analytically by David Rosenwasser and Jill Srephen.
4. Style: Lessons in Clarity and Grace by Joseph M. Williams and Joseph Bizup.
5. The Element of Style by William Struck Jr. and E.B. White.
6. Good Reasons with Contemporary Arguments by Lester Faigley and Jack Selzer.
7. Writing to Learn: How to Write – Clearly About Any Subject at All by William Zinsser.
8. The Norton Field Guido to Writing by Richard Bullock, Maureen Daly Goggin and Francine Weinberg.
9. The Art of Styling Sentences by Ann Longkinfe and K.D Sullivan.
10. Writing Today by Richard Johnson-Sheehan and Charles Paine.

Course Name:	**Civics and Community Engagement**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course is designed to provide students with fundamental knowledge about civics, citizenship, and community engagement. In this course, the students will learn about the essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society, which will help them, apply theoretical knowledge to real-world situations to make a positive impact on their communities.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Demonstrate fundamental understanding of civics, government, citizenship and civil society.	-
CLO-2	Understand the concept of community and recognize the	-

	significance of community engagement for individuals and groups.	
CLO-3	Recognize the importance of diversity and inclusivity for societal harmony and peaceful co- existence.	-

Course Outline:

Civics and Citizenship: Concepts of civics, citizenship, and civic engagement. Foundations of modern society and citizenship. Types of citizenship: active, participatory, digital, etc. State, Government, and Civil Society: Structure and functions of government in Pakistan. The relationship between democracy and civil society. Right to vote and importance of political participation and representation. 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.). 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. Advocacy and Activism: Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements. 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. 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.

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

1. Civics Today: Citizenship, Economics, & You by McGraw-Hill Education.
2. Citizenship in Diverse Societies by Will Kymlicka and Wayne Norman.
3. Engaging Youth in Civic Life by James Youniss and Peter Levine.
4. Digital Citizenship in Action: Empowering Students to Engage in Online Communities by Kristen Mattson.
5. Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education by Graham Pike and David Selby.
6. Community Engagement: Principles, Strategies, and Practices by Becky J. Feldpausch and Susan M. Omilian.
7. Creating Social Change: A Blueprint for a Better World by Matthew Clarke and Marie- Monique Steckel.

Course Name:	**Introduction to Management**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This is an introductory course about the management of organizations applicable to all types of enterprises regarding planning, organizing, leading, and controlling. It equips students to effectively work with and through others in an organization.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the key concepts and theory of the management of an organization	-
CLO-2	Hold informed conversations with functional specialists and	-

	understand how to draw effectively on their expertise in managing organizations.	
CLO-3	Demonstrate empirical investigative skills by producing an in-depth analysis of a management situation usually presented through case studies, resulting in recommendations for a program of action.	-
CLO-4	Recognize the need to take a holistic approach to performance improvement rather than a narrowly functional approach.	-

Course Outline:

Management, organization, and management process. Organizational theories and different approaches to management. The organizational culture and the manager. The external environment and the manager. The internal environment and the manager. Planning: Process of planning and MBO, effective strategic planning. Decision-making: The manager's role as decision maker, decision-making process. Basics of strategic management: case of strategic management, strategic management process. Organizational structure, types of organizational structures. Human resource management (HRM), HRM processes. Team work and group behavior. Leadership and its characteristics, styles and behaviors. The process of control and its standards.

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

1. Management by Stephen Robbins and Mary Coulter 14th Edition
2. Introduction to Management by Rutgers Business School, New Brunswick Edition, ISBN: 9781307093346
3. A Guide to the Project Management Body of Knowledge by Project Management Institute; Sixth Edition, (September 22, 2017)
4. The New One Minute Manager by Ken Blanchard and Spencer Johnson, William Morrow; 1st Edition (May 5, 2015)

Course Name:	**Professional Practices**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	A Computing graduate as a professional has some responsibilities for society. This course develops student understanding of historical, social, economic, ethical, and professional issues related to the discipline of Computing. It identifies key sources for information and opinions about professionalism and ethics. Students analyze, evaluate, and assess ethical and professional computing case studies.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the concepts of key, ethical, managerial, and legal issues typically encountered by an IT professional.	C2 (Understand)
CLO-2	Identify, access, and critically review appropriate and relevant literature drawn from academic, technical, legal, and professional business sources.	C3(Apply)
CLO-3	Evaluate and critically reflect upon self-presentation.	C5 (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 Materials (or use any other standard and latest books):

1. Professional Issues in Software Engineering by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, CRC Press; 3rd Edition (2000). ISBN-10: 0748409513
2. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition (January 3, 2009). ISBN-10: 0131112414
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (3rd Edition) by Sara Baase, Prentice Hall; 3rd Edition (2008). ISBN-10: 0136008488
4. Applied Professional Ethics by Gregory R. Beabout, University Press of America (1993). ISBN-10: 0819193747.

Course Name:	**Entrepreneurship**
Credit Hours:	2 (2-0)
Contact Hours:	Theory: 2 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course aims to provide students with a basic understanding of the principles and practices of entrepreneurship. It also aims to cultivate an entrepreneurial mindset and equip students with the knowledge and skills necessary to start, manage, and grow their ventures.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the principles and practices of entrepreneurship	-
CLO-2	Equip students with financial literacy and export management to gain a holistic understanding of business in priority areas of the economy	-
CLO-3	To enable students to apply the gained knowledge in developing business plans to start and initiate their ventures.	-

Course Outline:

Entrepreneurship: Fundamentals, Entrepreneurship, Entrepreneur, Entrepreneur vs. Manager, Economic Empowerment/Development/Upliftment. The Entrepreneurial Mindset: Assessment, Feedback, Personal Entrepreneurial Characteristics/Competencies (PECs), Successful Entrepreneur & Reasons for starting own Business. Creating & Starting the Venture: Creativity & the sources of new business idea, Assessing business opportunities, Methods of generating ideas, SWOT frame & analysis, PLC, Product Life Cycle, E-Commerce, Business Startup & Growth. Business plan development: Scope and Value of Business Plan. Marketing, Production/Technical, Organizational, and Financial Planning.

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

1. Robert D. Hisrich & Michael P. Peter "Entrepreneurship" (McGraw Hill) 5th Edition International edition
2. Bruce A. Kirchott "Entrepreneurship & Dynamic Capital"
3. Zafar Altaf (Croom Helm) "Entrepreneurship in the third world"
4. Robert J. Calvin "Entrepreneurial Management" (Tata McGraw Hill Edition)

2.8. Deficiency Courses

Course Name:	**Mathematics A for Medical Students**
Credit Hours:	Non-credit, deficiency course for FSc Pre-Medical Students (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	Mathematics at SSC level
Course Introduction:	To introduce the basics of functions with a detailed analysis of elementary functions including exponential, logarithmic and trigonometric functions

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To enable students with FSc (Pre-Medical) to understand the basic mathematics and its applications.	-

Course Outline:

Sets, Real Numbers and Their Properties, Polynomials, Linear and Quadratic Equations, Inequalities, Relations and Functions, Representing Functions, Linear and Quadratic Functions, Exponential and Logarithmic Functions, Trigonometric Functions, Graphs of Trigonometric Functions, Inverse Functions, Trigonometric Identities, The Law of Sines, The Law of Cosines, Complex Numbers, De Moivre's Theorem.

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

1. Margaret L. Lial, John Hornsby, David I. Schneider, Callie J. Daniels, "Precalculus", Pearson, 6th Edition, 2017
2. Sullivan, M., "Precalculus", Pearson, 10th Edition, 2016
3. Stewart, J., Redlin, L., Watson, S., "Precalculus, Mathematics for Calculus", CENGAGE Learning, 7th Edition, 2016
4. Kirkpatrick, C., "Functions 11", Nelson, 1st Edition, 2008

Course Name:	**Mathematics B for Medical Students**
Credit Hours:	Non-credit, deficiency course for FSc Pre-Medical Students (3-0)
Contact Hours:	Theory: 3 Hours, Practical: 0 Hours
Pre-requisites:	Mathematics A
Course Introduction:	To introduce the concept of matrices, conic section, basic probability theory, limits, basics of derivatives and basics of definite integrals

CLO No.	Course Learning Outcomes	Bloom Taxonomy

- - -

Course Outline:
System of Linear Equations, Matrices and Determinants, Solving System of Linear Equations in Matrix Form, Circles, Parabolas, Ellipses, Hyperbolas, Sequences and Series, The Binomial Theorem, Mathematical Induction, Basics of Counting Theory, Basics of Probability, Introduction to Limits and Continuity, Tangent Lines and Derivatives, Area and Definite Integral.

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

1. John Hornsby, Margaret L. Lial, Gary Rockswold, "A Graphical Approach to Precalculus with Limits", Pearson, 7th Edition, 2019
2. Margaret L. Lial, John Hornsby, David I. Schneider, Callie J. Daniels, "Precalculus", Pearson, 6th Edition, 2017
3. Ron Larson, Robert Hostetler, Bruce H. Edwards, "Precalculs with Limits", Brooks/Cole, 7th Edition, 2016
4. Sullivan, M., "Precalculus", Pearson, 10th Edition, 2016
5. Stewart, J., Redlin, L., Watson, S., "Precalculus, Mathematics for Calculus", CENGAGE Learning, 7th Edition, 2016

2.9. Tajweed, Quran and Hadith

Course Name:	**Tajweed Ul Quran**	
Credit Hours:	Non-credit course (1-0)	
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours	
Pre-requisites:	None	
Course Introduction:	To introduce students with the basics of Tajweed Ul Quran so that they can easily and properly recite the Holy Quran.	
CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	To enable students to understand the basics of Tajweed so that they can easily and properly recite the Holy Quran.	C2 (Understand)

Course Outline:
The Islamic Studies course instructor will select and teach essential aspects of Tajweed Ul Quran to enable students understand how to properly recite the Holy Quran.

Reference Materials (or use any other standard and latest books recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Ifham-ut-Tajweed by Qari Muhammad Mushtaq Anwar
2. Tajweed Rules In Urdu by TadeebulQuran
3. Learn Quran Tajweed Urdu by Tariq

Course Name:	**Understanding Quran-I: Selected Verses**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected verses of the Holy Quran with translation and Tafseer.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	To enable students to understand the Holy Quran by translation and Tafseer of some selected verses.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected verses from the Holy Quran, with the aim to focus ethical and social issues, recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other standard and latest books recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Tafseer Zia-ul-Quran by Pir Muhammad Karam Shah al-Azhari
2. Ma'ariful Quran by Sheikh Mufti Muhammad Qasim Attari
3. Tafseer-e-Uthmani by Sheikh Mahmoodul Hasan
4. Easy Tafseer by Shakeel Zahid

Course Name:	**Understanding Quran-II: Selected Verses**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected verses of the Holy Quran with translation and Tafseer.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	To enable students to understand the Holy Quran by translation and Tafseer of some selected verses.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected verses from the Holy Quran, with the aim to focus ethical and social issues, recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other standard and latest books recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Tafseer Zia-ul-Quran by Pir Muhammad Karam Shah al-Azhari
2. Ma'ariful Quran by Sheikh Mufti Muhammad Qasim Attari
3. Tafseer-e-Uthmani by Sheikh Mahmoodul Hasan
4. Easy Tafseer by Shakeel Zahid

Course Name:	**Understanding Quran-III: Selected Verses**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected verses of the Holy Quran with translation and Tafseer.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To enable students to understand the Holy Quran by translation and Tafseer of some selected verses.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected verses from the Holy Quran, with the aim to focus ethical and social issues, recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other standard and latest books recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Tafseer Zia-ul-Quran by Pir Muhammad Karam Shah al-Azhari
2. Ma'ariful Quran by Sheikh Mufti Muhammad Qasim Attari
3. Tafseer-e-Uthmani by Sheikh Mahmoodul Hasan
4. Easy Tafseer by Shakeel Zahid

Course Name:	**Understanding Quran-IV: Selected Verses**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected verses of the Holy Quran with translation and Tafseer.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To enable students to understand the Holy Quran by translation and Tafseer of some selected verses.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected verses from the Holy Quran, with the aim to focus ethical and social issues, recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other standard and latest books recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Tafseer Zia-ul-Quran by Pir Muhammad Karam Shah al-Azhari
2. Ma'ariful Quran by Sheikh Mufti Muhammad Qasim Attari
3. Tafseer-e-Uthmani by Sheikh Mahmoodul Hasan
4. Easy Tafseer by Shakeel Zahid

Course Name:	**Understanding Quran-V: Selected Verses**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected verses of the Holy Quran with translation and Tafseer.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To enable students to understand the Holy Quran by translation and Tafseer of some selected verses.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected verses from the Holy Quran, with the aim to focus ethical and social issues, recommended and approved by the Department of Islamic Studies.

Reference Materials (or use any other standard and latest books recommended by the Department of Islamic Studies, SBBU, Sheringal):

5. Tafseer Zia-ul-Quran by Pir Muhammad Karam Shah al-Azhari
6. Ma'ariful Quran by Sheikh Mufti Muhammad Qasim Attari
7. Tafseer-e-Uthmani by Sheikh Mahmoodul Hasan
8. Easy Tafseer by Shakeel Zahid

Course Name:	**Seerah-I**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected events from the life of the Holy Prophet, Muhammad (PBUH) as a guidance for the BS students.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To enable students to learn about the life of the Holy Prophet, Muhammad (PBUH) as a guidance for the BS students.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected events from the life of the Holy Prophet Muhammad صلی اللہ علیہ وسلم with the aim to focus ethical and social issues by following any authentic Tafseer Ul Quran recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other any authentic book on the life/Seerah of Prophet Muhammad صلی اللہ علیہ وسلم recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Ar-Raheeq Al-Makhtum by Safiur Rahman Al-Mubarakpuri
2. Seerat-e-Mustafa by Hadhrat Moulana Idris Kandehlawi
3. Seerat Nigari by Dr. Yasin Mazhar Siddiqui
4. Seerat-un-Nabi by Shibli Nomani and Sulaiman Nadvi

Course Name:	**Seerah-II**
Credit Hours:	Non-credit course (1-0)
Contact Hours:	Theory: 1 Hours, Practical: 0 Hours
Pre-requisites:	None
Course Introduction:	This course teaches selected events from the life of the Holy Prophet, Muhammad (PBUH) as a guidance for the BS students.

CLO No.	**Course Learning Outcomes**	**Bloom Taxonomy**
CLO-1	To enable students to learn about the life of the Holy Prophet, Muhammad (PBUH) as a guidance for the BS students.	C2 (Understand)

Course Outline:

The Islamic Studies course instructor will teach selected events from the life of the Holy Prophet Muhammad صلی اللہ علیہ وسلم with the aim to focus ethical and social issues by following any authentic Tafseer Ul Quran recommended and approved by Department of Islamic Studies.

Reference Materials (or use any other any authentic book on the life/Seerah of Prophet Muhammad صلی اللہ علیہ وسلم recommended by Department of Islamic Studies, SBBU, Sheringal):

1. Ar-Raheeq Al-Makhtum by Safiur Rahman Al-Mubarakpuri
2. Seerat-e-Mustafa by Hadhrat Moulana Idris Kandehlawi
3. Seerat Nigari by Dr. Yasin Mazhar Siddiqui
4. Seerat-un-Nabi by Shibli Nomani and Sulaiman Nadvi