Annexure-A

Revised Curriculum for BS Computer Science

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF PESHAWAR
SESSION 2024

1   Introduction

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. Specifically, Computer Science is the application of a systematic, disciplined and quantifiable approach to the design, development, operation, and maintenance of software systems. It is in fact the practice of designing and implementing large, reliable, efficient and economical software by applying well established principles and practices.
Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in several fields including machine learning, information management, World Wide Web, bioinformatics, and other exciting areas. Advanced principles, concepts, methods, approaches and technologies emerge with the passage of time to satisfy the dynamic and wide range nature of Computer Science. Therefore, BS CS program curriculum needs to be revised regularly to encompass the advanced ideas and technologies and enables students to meet the growing demands of the field and software industry to help in the economic growth of the country.

2   Rationale of Revision

Computer Science is a rapidly expanding field. Its uses in society are ubiquitous. Since the inception of the Department of Computer Science, the department has routinely revised its courses to keep up with the new developments in the field of Computer Science and needs of society. A Computer Science graduate typically finds a job as a technologist, developer/software engineer, educator, or a researcher and these roles require competency in different knowledge areas. Therefore, an effort was made to provide students with a balanced mix of skills and knowledge in all the important areas in the previous revision. The knowledge areas were grouped into categories of theory core, application core, advanced applications, and research specializations along in strong compliance with the HEC proposed framework. The categories provided an expended breadth of the course work at the undergraduate level along with preparation for further research studies.
The HEC-NCEAC (National Computing Education Accreditation Council) is a recognized accreditor of bachelor level computing programs in Pakistan. It ensures the quality of computing degree programs in Higher Education institutions in Pakistan and fostering the intellectual development of students interested in pursuing computing profession. To cater challenges and enhance quality of BS CS program to meet international standards, HEC-NCEAC has revised BS CS curriculum which is deemed to be compulsory adopted by the Higher Education institutions in Pakistan to facilitate in accreditation process. The present revision in BS CS program is motivated not only by the new trends in Computer Science research and applications domains but also to it align with the HEC-NCEAC BS CS curriculum model/framework. The curriculum model/framework is dynamic and provides students to learn theoretical and practical understanding of Computer Science. Apart from the above requirement, the present revision is also required to incorporate the HEC Undergraduate policy 2023 in the BS CS program.

The BS CS program needs to be transformed while keeping in view the latest knowledge-based education philosophy. To prepare students for attaining educational objectives by ensuring that students demonstrate achievements in different program outcomes. The BS CS program curriculum needs to be revised and restructured to satisfy BS CS program educational objectives.

2.1 Major Revisions

The following notable changes have been made in the existing BS CS 2017 semester plan and courses.

1) Semesters have been reorganized with careful focus on computing core (theoretical foundations) in earlier semesters, followed by more domain core and electives, applied and advanced aspects in the later semesters. This will help to groom students, as perspective software developers as well as researchers, in a logical and sustainable way.
2) Along with this, it is also kept in mind that the curriculum is in line with the HEC-NCEAC guidelines of BS CS curriculum and HEC undergraduate policy 2023.
3) Apart from the existing courses, new courses have been added in the different categories to train students in the latest technologies of Computer Science.
4) Course titles of the existing courses have been changed, where needed, to clearly reflect their contents.
5) Contents of existing courses have been revised to incorporate topics related to recent trends in Computer Science, to equip students with up-to-date information in Computer Science theory and research.
6) Reference books have been updated where needed.
7) New course codes have been allotted to the existing and new courses according to the new reorganization in the different semesters.
8) Courses' credit hours have been changed to reflect the theory and practical content of a course and contact hours.
9) Practical labs have been made mandatory with all courses, where required, to make the courses more practically oriented instead of only theory based. This will help to enhance practical/ implementation skill of students.
10) Lists of Domain Electives, Elective Supporting and in General Educations (Natural Sciences and Social Sciences) courses are extended so that the students can be exposed to a diverse set of related fields.
11) Course codes have been assigned as per UOP policy.

3 Program Educational Objectives' (PEOs)

PEOs describe what the students are expected to achieve after 04 years of their graduation. For BS CS program, the following three PEOs have been defined:

- **PEO-1:** Equipped with in-depth computer science knowledge (concepts, theories and practices) to apply and build professional careers in computing and associated technological fields to the best of society and industry.
- **PEO-2:** Having excellent problem solving and entrepreneurial skills to achieve professional endeavors/practices with effective communication skills, work as a team

member in collaborative environments and excel in leadership capacity with highest legal, ethical and moral standards.

- **PEO-3:** Prepared and zealous for life-long learning and continuous educational and interpersonal skills development to achieve sustainable career development and professional growth.

4   Program Learning Outcomes (PLOs)

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

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

| 9 | Ethics | Understand and commit to professional ethics, responsibilities, and norms of professional computing practice. |
| 10 | Life-long Learning | Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional, |

5 Mapping of PEOs and PLOs

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

6. HEC-NCEAC Curriculum Model for BS CS

Structure for HEC-NCEAC BS CS is:

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

#	Semester #	Course Code	Pre-Requisite	Course Title	Domain	Credit Hours
Computing Core - 14 Courses (46/133)						
1	1	CS102	-	Programming Fundamentals	Computing Core	4(3-3)
2	2	CS123	CS102	Object Oriented Programming	Computing Core	4(3-3)
3	2	CS122	-	Digital Logic Design	Computing Core	3(2-3)
4	2	CS121	-	Computer Networks	Computing Core	3(2-3)
5	3	CS206	-	Database Systems	Computing Core	4(3-3)
6	3	CS202	CS123	Data Structures	Computing Core	4(3-3)
7	3	CS204	-	Software Engineering	Computing Core	3(3-0)
8	3	CS201	CS123	Artificial Intelligence	Computing Core	3(2-3)
9	4	CS203	-	Information Security	Computing Core	3(2-3)
10	4	CS208	CS202	Operating Systems	Computing Core	3(2-3)
11	4	CS205	CS202	Analysis of Algorithms	Computing Core	3(3-0)
12	4	CS207	CS122	Computer Organization and Assembly Language	Computing Core	3(2-3)
13	7	CS401	-	Final Year Project – I	Computing Core	2(0-6)

14	8	CS402	CS401	Final Year Project – II	Computing Core	4(0-12)
Domain Core - 6 Courses (18/133)						
15	5	CS311	CS202	Theory of Automata	Domain Core	3(2-3)
16	5	CS301	CS121	Advanced Database Management Systems	Domain Core	3(2-3)
17	6	CS319	CS102	Human Computer Interaction	Domain Core	3(2-3)
18	6	CS327	CS207	Computer Architecture	Domain Core	3(2-3)
19	7	CS326	CS311	Compiler Construction	Domain Core	3(2-3)
20	8	CS403	CS123, CS208	Parallel and Distributed Computing	Domain Core	3(2-3)
Domain Elective - 7 Courses (21/133)						
21	5-8	CS323	CS123	Web Technologies	Domain Elective	3(2-3)
22	5-8	CS314	CS123	Advanced Programming	Domain Elective	3(2-3)
23	5-8	CS318	CS201	Data Mining	Domain Elective	3(2-3)
24	5-8	CS307	CS201	Machine Learning	Domain Elective	3(2-3)
25	5-8	CS324	CS123	Object Oriented Analysis and Design	Domain Elective	3(2-3)
26	5-8	CS341	CS314	Mobile Application Development	Domain Elective	3(2-3)
27	5-8	CS349	CS323	Web Engineering	Domain Elective	3(2-3)
	5-8	CS303	CS203	Cyber Security	Domain Elective	3(2-3)
	5-8	CS410	CS341	Advanced Mobile Application Development	Domain Elective	3(2-3)
	5-8	CS417	CS208	Cloud Computing	Domain Elective	3(2-3)
	5-8	CS421	CS204	Software Testing and Quality Assurance	Domain Elective	3(2-3)

	5-8	CS420	CS307	Natural Language Processing	Domain Elective	3(2-3)
	5-8	CS353	CS201	Digital Image Processing	Domain Elective	3(2-3)
	5-8	CS354	CS206	Fundamentals of Data Warehousing	Domain Elective	3(2-3)

Mathematics and Supporting - 4 Courses (12/133)

28	1			Probability & Statistics	Mathematics and Supporting	3(3-0)
29	4			Multivariable Calculus	Mathematics and Supporting	3(3-0)
30	5			Applied Linear Algebra	Mathematics and Supporting	3(3-0)
31	7			Technical and Business Writing	Mathematics and Supporting	3(3-0)

Elective Supporting - 1 Course (3/133)

32	5	MATH-432	-	Computation in MATLAB	Elective Supporting	3(2-3)
Any other University of Peshawar approved computer science related course.						

General Education (HEC UG Education Policy) - 12 Courses (33/133)

33	1	CS101	-	Applications of Information and Communication Technologies (ICT)	General Education	3(2-3)
34	1		-	Functional English	General Education	3(3-0)
35	2		-	Expository Writing	General Education	3(3-0)
36	2	CS120	-	Quantitative Reasoning – 1 (Discrete Structures)	General Education	3(3-0)
37	3		-	Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	General Education	3(3-0)

38	1		-	Islamic Studies	General Education	2(2-0)
	1		-	Religious Education/Ethics	General Education	
39	1		-	Ideology and Constitution of Pakistan	General Education	2(2-0)
40	4		-	Natural Sciences	General Education	3(2-3)
41	7		-	Social Sciences	General Education	3(3-0)
42	7	BA565	-	Entrepreneurship	General Education	3(3-0)
43	8		-	Arts & Humanities	General Education	3(3-0)
44	8		-	Civics and Community Engagement	General Education	2(2-0)

Social Science Courses Pool

#	Course Code	Course Title	Credit Hours	Department
1	SW-682	Project Planning and Management	3(3-0)	Department of Social Work
2	BA 324	Principles of Marketing	3(3-0)	Institute of Management Studies
3	BA 322	Management	3(3-0)	Institute of Management Studies
4	Psy-101	Introduction to Psychology – I	3(3-0)	Department of Psychology
Any other University of Peshawar approved course from social sciences.				

Arts & Humanities Courses Pool

#	Course Code	Course Title	Credit Hours	Department
1	CS423	Professional Practices	3(3-0)	Department of Computer Science
2	HIST-106	Introduction to History	3(3-0)	Department of History
3	Phil:311	An introduction to Philosophy	3(3-0)	Department of Philosophy
Any other University of Peshawar approved course from arts and humanities.				

Natural Sciences Courses Pool

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

7   Semester Plan for BS CS

The courses are semester-wise distributed while keeping in view and considering the NCEAC guidelines and HEC UG policy.

#	Course Code	Course Title	Domain	Credit Hours
		Semester 1		
1	CS102	Programming Fundamentals	Computing Core	4(3-3)
2	CS101	Applications of Information & Communication Technologies	General Education	3(2-3)
3		Functional English	General Education	3(3-0)
4		Probability & Statistics	Mathematics and Supporting	3(3-0)
5		Islamic Studies	General Education	2(2-0)
		Religious Study/Ethics		
6		Ideology and Constitution of Pakistan	General Education	2(2-0)
			Total Cr. Hrs	**17(15-06)**
		Semester 2		
7	CS123	Object Oriented Programming	Computing Core	4(3-3)
8	CS122	Digital Logic Design	Computing Core	3(2-3)
9	CS120	Discrete Structures	Geneal Education	3(3-0)
10		Expository Writing	General Education	3(3-0)
11	CS121	Computer Networks	Computing Core	3(2-3)
			Total Cr. Hrs	**16(13-09)**
		Semester 3		
12	CS202	Data Structures	Computing Core	4(3-3)
13		Calculus and Analytical Geometry	General Education	3(3-0)
14	CS201	Artificial Intelligence	Computing Core	3(2-3)
15	CS204	Software Engineering	Computing Core	3(3-0)
16	CS206	Database Systems	Computing Core	4(3-3)
			Total Cr. Hrs	**17(14-09)**
		Semester 4		
17	CS207	Computer Organization and Assembly Language	Computing Core	3(2-3)
18	CS208	Operating Systems	Computing Core	3(2-3)
19	CS205	Analysis of Algorithms	Computing Core	3(3-0)
20		Natural Sciences	General Education	3(2-3)
21	CS203	Information Security	Computing Core	3(2-3)
22		Multivariate Calculus	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**18(14-12)**
		Semester 5		
23	CS3XX	Domain Core 1	Domain Core	3(3-0)
24	CS3XX	Domain Core 2	Domain Core	3(2-3)

25	CS3XX	Domain Elective 1	Domain Elective	3(2-3)
26	CS3XX	Domain Elective 2	Domain Elective	3(2-3)
27		Elective Supporting	Elective Supporting	3(2-3)
28		Applied Linear Algebra	Mathematics and Supporting	3(3-0)
			Total Cr. Hrs	**18(14-12)**
Semester 6				
29	CS3XX	Domain Core 3	Domain Core	3(2-3)
30	CS3XX	Domain Core 4	Domain Core	3(2-3)
31	CS3XX	Domain Elective 3	Domain Core	3(2-3)
32	CS3XX	Domain Elective 4	Domain Elective	3(2-3)
33	CS3XX	Domain Elective 5	Domain Elective	3(2-3)
			Total Cr. Hrs	**15(10-15)**
Semester 7				
34	CS4XX	Domain Core 5	Domain Core	3(2-3)
35	CS4XX	Domain Elective 6	Domain Elective	3(2-3)
36		Technical and Business Writing	Mathematics and Supporting	3(3-0)
37	BA565	Entrepreneurship	General Education	3(3-0)
38		Social Sciences	General Education	3(3-0)
39	CS401	Final Year Project – I	Computing Core	2(0-6)
			Total Cr. Hrs	**17(13 -12)**
Semester 8				
40	CS4XX	Domain Core 6	Domain Core	3(2-3)
41	CS4XX	Domain Elective 7	Domain Elective	3(2-3)
42		Arts and Humanities	General Education	3(3-0)
43		Civics and Community Engagement	General Education	2(2-0)
44	CS402	Final Year Project – II	Computing Core	4(0-12)
			Total Cr. Hrs	**15(09-18)**

8 Revision at a Glance

During revision, the following changes and additions are preformed:

8.1 Computing Core Courses

#	Course Code	Course Title	Credit Hours	Remarks
1	CS102	Programming Fundamentals	4(3-3)	• Title is kept same • Course code is changed • Course contents are kept same • Lab contact hours is changed
2	CS123	Object Oriented Programming	4(3-3)	• Title is kept same • Course code is changed • Course contents are kept same • Lab contact hours are changed
3	CS122	Digital Logic Design	3(2-3)	• Course code is changed • Title is kept same • Course contents are kept same • Credit/contact hours are changed • Lab credit/contact hours are included • Books are updated
4	CS206	Database Systems	4(3-3)	• Course moved from semester 4 • Course code is changed • Title is kept same • Course contents are updated • Books are updated • Credit hours are changed • Lab contact hours are changed
5	CS202	Data Structures	4(3-3)	• Title is changed (previously was Data Structures and Algorithms) • Course code is changed • Course contents are kept same • Lab contact hours are changed
6	CS204	Software Engineering	3(3-0)	• Course moved from semester 6 • Course code is changed • Title is kept same • Course contents are updated • Books are updated • Contact hours are changed • Lab contact hours are included.
7	CS201	Artificial Intelligence	3(2-3)	• Course code is changed • Title is kept same • Course contents are updated • Books are updated • Contact hours are changed • Lab contact hours are included.

#	Course Code	Course Title	Credit Hours	Remarks
8	CS121	Computer Networks	3(2-3)	• Course moved from semester 4 • Course code is changed • Title is kept same • Course contents are kept same • Credit/contact hours are changed • Lab contact hours are changed
9	CS208	Operating Systems	3(2-3)	• Title is kept same • Course code is changed • Course contents are kept same • Contact hours are changed • Lab contact hours are included
10	CS205	Analysis of Algorithms	3(3-0)	• Course moved from semester 5 • Title is changed (previously was Design and Analysis of Algorithms) • Course code is changed • Course contents are updated • Books are updated
11	CS207	Computer Organization and Assembly Language	3(2-3)	• Title is changed (previously was Computer Organization and Architecture) • Course move from semester 6 • Course code is changed • Course contents are updated • Books are updated • Credit/contact hours are changed • Lab contact hours are included
12	CS203	Information Security	3(2-3)	• Course moved from semester 6 • Title is kept same • Course contents are kept same • Contact hours are changed • Lab contact hours are included
13	CS401	Final Year Project – I	2(0-6)	• Course code is changed • Title is kept same • Credit/contact hours are changed
14	CS402	Final Year Project – II	4(0-12)	• Course code is changed • Title is kept same • Credit/contact hours are changed

8.2   Domain Core Courses

#	Course Code	Course Title	Credit Hours	Remarks
1	CS311	Theory of Automata	3(3-0)	• Title is kept same • Course code is changed • Course contents are kept same • Contact hours are changed • Lab contact hours are included

2	CS301	Advanced Database Management Systems	3(2-3)	• Course moved from semester 7 • Title is kept same • Course code is changed • Course contents are updated • Contact hours are changed • Lab contact hours are included
3	CS319	Human Computer Interaction	3(2-3)	• Title is kept same • Course code is changed • Course contents are updated • Contact hours are changed • Lab contact hours are included
4	CS327	Computer Architecture	3(2-3)	• Title is changed (previously was Computer Organization and Architecture) • Course code is changed • Course contents kept same • Credit/contact hours are changed • Lab contact hours are included
5	CS326	Compiler Construction	3(2-3)	• Title is kept same • Course code is changed • Course contents are kept same • Credit/contact hours are changed • Lab contact hours are included
6	CS403	Parallel and Distributed Computing	3(2-3)	• Title is changed (previously was introduction to parallel computing) • Course contents are updated • Contact hours are changed • Lab contact hours are included

8.3   Domain Elective Courses

#	Course Code	Course Title	Credit Hours	Remarks
1	CS323	Web Technologies	3(2-3)	• Course code is changed • Title is kept same • Course contents are updated • Credit/contact hours are changed • Lab contact hours are changed
2	CS324	Object Oriented Analysis and Design	3(2-3)	• Course code is changed • Title is kept same • Course contents are kept same • Credit/contact hours are changed • Lab contact hours are changed
3	CS314	Advanced Programming	3(2-3)	• Title is kept same • Course code is changed • Course contents are kept same • Credit/contact hours are changed

#	Course Code	Course Title	Credit Hours	Remarks
				• Lab contact hours are changed
4	CS341	Mobile Application Development	3(2-3)	• Course code is changed • Title is kept changed (previously was Mobile Applications Development) • Course contents are updated • Credit/contact hours are changed • Lab contact hours are changed
5	CS349	Web Engineering	3(2-3)	• Course moved from semester 7 • Title is kept same • Course contents is kept same • Credit/contact hours are changed • Lab contact hours are included
6	CS303	Cyber Security	3(2-3)	• New course is added
7	CS410	Advanced Mobile Application Development	3(2-3)	• New course is added
8	CS417	Cloud Computing	3(2-3)	• New course is added
9	CS421	Software Testing and Quality Assurance	3(2-3)	• New course is added
10	CS318	Data Mining	3(2-3)	• New course is added
11	CS307	Machine Learning	3(2-3)	• Course code is changed • Title is kept same • Course contents are changed • Credit/contact hours are changed • Lab contact hours are included
12	CS420	Natural Language Processing	3(2-3)	• Course code is changed • Title is kept same • Course contents are changed • Credit/contact hours are changed • Lab contact hours are included
13	CS353	Digital Image Processing	3(2-3)	• Course code is changed • Title is kept same • Course contents are kept same • Credit/contact hours are changed • Lab contact hours are included
14		Fundamentals of Data Warehousing	3(2-3)	• Course code is changed • Title is kept same • Course contents are kept same • Credit/contact hours are changed • Lab contact hours are included

8.4   Mathematics and Supporting Courses

#	Course Code	Course Title	Credit Hours	Remarks
1		Probability & Statistics	3(3-0)	• Course code is changed

#	Course Code	Course Title	Credit Hours	Remarks
				• Title is kept same • Course contents are kept same
2		Multivariable Calculus	3(3-0)	• Course moved from semester 2 • Course code is changed • Title is kept same • Course contents are kept same
3		Applied Linear Algebra	3(3-0)	• Course moved from semester 3 • Course code is changed • Title is changed (previously was linear algebra) • Course contents are kept same
4		Technical and Business Writing	3(3-0)	• Title is kept same • Course code is changed • Course contents are kept same

8.5 Elective Supporting Courses

#	Course Code	Course Title	Credit Hours	Remarks
1	MATH-432	Computation in MATLAB	3(2-3)	• Course is moved from Semester 3 • Course code is kept same • Course contents and books are kept same

8.6 General Education Courses

#	Course Code	Course Title	Credit Hours	Remarks
1	CS101	Applications of Information and Communication Technologies (ICT)	3(2-3)	• Course is added as per HEC UG policy guidelines • Course code is changed • Title is changed as per HEC UG policy guidelines (previously was Fundamentals of Computers) • Course contents are updated • Books are updated • Lab contact hours are changed
2		Functional English	3(3-0)	• Course is added as per HEC UG policy guidelines • Course code is changed • Title is kept same • Course contents are updated • Books are updated
3		Expository Writing	3(3-0)	• Course is added as per HEC UG policy guidelines • Replace previously communication skills course

4		Quantitative Reasoning – 1 (Discrete Structures)	3(3-0)	• Title is kept same • Course code is changed • Course contents are updated • Books are updated
5		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	3(3-0)	• Course moved from semester 1 • Course code is changed • Title is kept same • Course contents are updated • Books are updated
6		Islamic Studies	2(2-0)	• Ccourse is added as per HEC UG policy guidelines • Course code is changed • Title is changed as per HEC UG policy guidelines (previously was Pakistan Studies/Islamic Studies) • Course contents are updated • Books are updated
		Religious Education/Ethics		
7		Ideology and Constitution of Pakistan	2(2-0)	• Course is added as per HEC UG policy guidelines • Course code is changed • Title is changed as per HEC UG policy guidelines (previously was Pakistan Studies/Islamic Studies) • Course contents are updated • Books are updated
8		Social Sciences	3(3-0)	• Course is added as per HEC UG policy guidelines
9		Natural Sciences	3(2-3)	• Course is added as per HEC UG policy guidelines of natural sciences
10		Arts & Humanities (Professional Practices)	3(3-0)	• Course is added as per HEC UG policy guidelines • Title is kept same • Course code is changed • Course contents are updated • Books are updated •
11		Civics and Community Engagement	2(2-0)	• Course is added as per HEC UG policy guidelines
12	BA565	Entrepreneurship	3(3-0)	• Course is added as per HEC UG policy guidelines • Title is kept same • Course code is changed • Course contents are kept same

9   Course Contents

9.1   Computing Core Courses

Course Name	Programming Fundamentals
Course Code	CS102
Course Area	Computing Core
Credit Hours	4 (3-3)
Contact Hours	3-3
Pre-requisites	None

Course Introduction

This course provides fundamental concepts of programming to freshmen. The courses is pre-requisite to many other courses, therefore, students are strongly advised to cover all contents and try to achieve CLOs to the maximum possible level. The course may be taught as language independent. Further, it is up to the university to choose any language for the practical/Lab purpose but that must be latest and market oriented. At the end of the course the students will be able to:

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

Course Outline

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

Reference Material

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

1. Dietel, Paul, and Harvey, Dietel. C++ How to Program. Prentice Hall, 2019.
2. Lafore, Robert. Object-Oriented Programming in C. Indianapolis, Sams, 2005.
3. Sahay, Sourav. Object Oriented Programming with C. Oxford University Press, 2012.
4. Kanetkar, Yashavant. Basic Programming in C++. BPB Publications, 2004.

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

Course Introduction

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

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

Course Outline

Object Oriented Programming (OOP) and its Significance as a Modeling Technique. Comparison of Structured Programming and OOP, Classes and Objects in C++, Abstraction, New User Defined Data Types, Creating Objects from Classes, Accessing Member, Access Specifiers, Member Functions, Defining Member Functions, Constructors and Properties, Default Constructor, Constructor Overloading, Copy Constructor, Deep Copy, Shallow Copy, Destructors, "this" Pointer, Constant Member Function, Static Variables, Accessing Static Data Member, Static Member Function, Comparison of Global Variables and Static Variable, Arrays of Objects, Pointer to Objects Templates, Function Templates, Class Templates, Data Encapsulation and Abstraction, Importance of Data Encapsulation and Abstraction, Correctly Using the Access Modifiers, Friend Functions, Composition, Aggregation, Operator Overloading, Overloading Assignment Operator, Friend Function and Operator Overloading,

Unary Operators Overloading, Inheritance and Importance, Inheritance in C++, Comparison of Overloading and Overriding, Hierarchy of Inheritance, Types of Inheritance, Private Inheritance, Protected Inheritance Multiple Inheritance Problem in Multiple Inheritance, Polymorphism and Importance, Virtual Functions, Static Binding, Dynamic Binding, Abstract Classes and Concrete Classes, Virtual Destructors, Virtual Functions and Pure Virtual Functions, Virtual Functions Usage, Dynamic Dispatch, Namespaces and Using Namespaces, Memory Management and Importance, Memory Areas(Heap, Stack), Use of new Operator, malloc() and calloc() Functions Calls.

Reference Material

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

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

Course Name	Digital Logic Design
Course Code	CS122
Course Area	Computing Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	None

Course Introduction

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

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

CLO-4	Understand the relationship between abstract logic characterizations and practical electrical implementations.

(C, 2 (Understand) appear in columns)

CLO-4 Understand the relationship between   C   2 (Understand)
abstract logic characterizations and
practical electrical implementations.

Course Outline

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

Reference Material

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

1. Morris, Mano. Digital Logic and Computer Design, 6th edition. Pearson Education India, 2009.
2. Floyd, Thomas. Digital Computer Electronics, 11th edition. Pearson Education India, 2014.
3. Mazumder, Pinaki, and Idongesit E. Ebong. Lectures on Digital Design Principles. River Publishers, 2023.

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

Course Introduction

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

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

Course Outline

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

Reference Material

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

1. Drozdek, Adam. Data Structures and Algorithms in C++, 4th Edition, Cengage Learning, 2012
2. Weiss, Mark. Data Structures and Algorithm Analysis in C++. 4th Edition. Pearson, 2013.
3. Miller, Bradley. et al. Problem Solving with Algorithms and Data Structures Using Python, 3rd Edition. Franklin, Beedle & Associates, 2023.
4. Lambert, Kenneth. Fundamentals of Python: Data Structures. 2nd Edition. Cengage Learning, 2018.
5. Weiss, Mark. Data Structures and Algorithm Analysis in Java. 3rd edition. Pearson, 2011.

Course Name	Database Systems
Course Code	CS206
Course Area	Computing Core
Credit Hours	4 (3-3)
Contact Hours	3-3
Pre-requisites	None

Course Introduction

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

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

Course Outline

Basic database concepts, Database approach vs. file based system, database architecture, three level schema architecture, data independence, relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints, relational algebra, selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Structured Query Language (SQL), Joins and sub-queries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, NoSQL systems.

Reference Material

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

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

Course Name	Software Engineering
Course Code	CS204
Course Area	Computing Core
Credit Hours	3 (3-0)

Contact Hours   3-0
Pre-requisites   None

Course Introduction

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

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

Course Outline

Professional software development, Software engineering practices, Software process structure, Traditional software process models, Agile software development, Agile process models(XP, Scrum), Agile development practices, Requirements engineering process, Functional and non-functional requirements, Model driven engineering, UML diagrams: Context models, Interaction models, Structural models, behavioral models, , Architectural design, Detailed design and implementation, , Design patterns, Coding standards, Software testing and quality assurance, Software deployment, maintenance, evolution, Overview of project management(Introduction to MS Project or related tool) Introduction to software development, environment (Concepts of Build, Continuous Integration/Continuous delivery, Configuration management (GitHub, GitLab, etc)

Reference Material

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

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

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

Course Introduction

Artificial Intelligence has emerged as one of the most significant and promising areas of computing. This course focuses on the foundations of AI and its basic techniques like Symbolic manipulations, Pattern Matching, Knowledge Representation, Decision Making and Appreciating the differences between Knowledge, Data and Code. AI programming language Python has been proposed for the practical work of this course.

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

Course Outline

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

Reference Material

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

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

Course Name	Computer Networks
Course Code	CS121
Course Area	Computing Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	None

Course Introduction

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

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

Course Outline

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

Reference Material

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

1. Stallings, Willaim. Data and Computer Communications. 10th Edition. Pearson, 2013

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

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

Course Introduction

This course will introduce the core concepts of operating systems, such as processes and threads, scheduling, synchronization, memory management, file systems, input and output device management and security. The course will consist of assigned reading, weekly lectures, a midterm and final exam, and a sequence of programming assignments. The goal of the readings and lectures is to introduce the core concepts. The goal of the programming assignments is to give students some exposure to operating system code. Students are expected to read the assigned materials prior to each class, and to participate in in-class discussions.

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

Course Outline

Introduction & Overview, Computer Organization, Interrupts, Components of Operating System, Processes & PCB, Process Creation, Process Management, Processes, Process States, Process State Models, Inter-Process Communication, Process Scheduling, Threads, Synchronization Issues, Busy Waiting Algorithm &Bakery Algorithm, TSL & Priority Inversion, Semaphores, Classical Synchronization Problems, Dead Locks, Deadlock Detection, Deadlock recovery, Deadlock Avoidance, Deadlock Prevention, Memory management, Real

Memory Organization and Management, Virtual Memory Organization: Paging, Segmentation, Virtual Memory Management: Placement, Replacement, and Fetch Strategies Input Output Management, File System.

Reference Material:

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

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

Course Name	Analysis of Algorithms
Course Code	CS205
Course Area	Computing Core
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	Data Structures

Course Introduction

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

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

algorithm. Trace and/or implement a string-matching algorithm.

Course Outline

Introduction; role of algorithms in computing, Analysis on nature of input and size of input Asymptotic notations; Big-O, Big Ω, Big Θ, little-o, little-ω, Sorting Algorithm analysis, loop invariants, Recursion and recurrence relations; Algorithm Design Techniques, Brute Force Approach, Divide-and-conquer approach; Merge, Quick Sort, Greedy approach; Dynamic programming; Elements of Dynamic Programming, Search trees; Heaps; Hashing; Graph algorithms, shortest paths, sparse graphs, String matching; Introduction to complexity classes.

Reference Material:

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

1. Cormen, Thomas, et al. Introduction to Algorithms. 4th Edition. The MIT Press, 2022.
2. Kleinberg, Jon, and Tardos, Eva. Algorithm Design. Pearson, 2005.
3. Sedgewick, Robert, and Wayne, Kevin. Algorithms. 4th Edition. Addison-Wesley Professional, 2011.

Course Name	Computer Organization and Assembly Language
Course Code	CS207
Course Area	Computing Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Digital Logic Design

Course Introduction

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

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

| CLO-3 | Solve the problems related to computer organization and assembly language. | C | 3 (Apply) |

Course Outline

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

Reference Material:

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

1. Patterson, David A., and John L. Hennessy. Computer Organization and Design. 6th Edition. Morgan Kaufmann, 2020.
2. Mano, M. Morris. Computer System Architecture. 3rd Edition. Prentice-Hall, Inc., 1993.
3. Duntemann, Jeff. Assembly language step-by-step: Programming with Linux. 3rd Edition. John Wiley & Sons, 2011.
4. Bryant, Randal E., and David Richard O'Hallaron. Computer systems: a programmer's perspective. 3rd Edition. Prentice Hall, 2016.
5. Britton, Robert. MIPS assembly language programming. 2003.

Course Name	Information Security
Course Code	CS203
Course Area	Computing Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	None

Course Introduction

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

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

Course Outline

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

Reference Material:

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

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

9.2   Domain Core Courses

Course Name	Theory of Automata
Course Code	CS311
Course Area	Domain Core

Credit Hours   3 (3-0)
Contact Hours   3-0
Pre-requisites   Object Oriented Programming

Course Introduction

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

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

Course Outline

Introduction to Language: Language as a set, string, string terminologies, alphabet, operations on languages (Union, Concatenation, Kleene Closure), Language Representation: Recursive Definition, Regular Expression (Basic Regular Expressions, Complex Regular Expressions using notational short hands), Grammars, Automata Introduction: Automata and Types of Automata, Parts of Automata, Determinism, Finite Automata (FA): Definition of FA, Elements of FA, Nondeterministic Finite Automata (NFA), Deterministic Finite Automata (DFA), Working of FA, Regular Expression to NFA conversion, NFA to DFA conversion, Minimization of number of states in a DFA, DFA coding in C language, Kleene's Theorem: Transition Graph (TG), Generalized Transition Graph (GTG), Statement and Proof of Kleene's Theorem, Finite Automata With output: Moore Machine, Mealy Machine, Moore=Mealy, Context Free Grammars: Definition, Derivation, Problems in Context Free Grammars (Ambiguity, Left Recursion, Common Prefixes), Methods for removal of these problems, Chomsky Normal Form (CNF), Pushdown Automata (PDA): Definition of PDA, Elements of PDA, Creation of PDA i.e. CFG=FA, Touring Machines: Definition of Turing Machines, Elements of Turing Machines, Creation of Turing Machines, Pumping Lemma.

Reference Material

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

1. Cohen, Daniel. Introduction to Computer Theory. New York, Wiley, 1997.

2. Kelley, Dean. Automata and Formal Languages: an introduction. Prentice-Hall, Inc., 1995.
3. Sipser, Michael. Introduction to the Theory of Computation. Cengage Learning, 2013.
4. Esparza, Javier, and Michael Blondin. Automata Theory. MIT Press, 2023.

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

Course Introduction

Advanced Database Management Systems is an extension to "Database Systems" course. The aim of the course is to enhance the previous knowledge of database systems by deepening the understanding of the theoretical and practical aspects of the 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 expose emerging research issues in database systems and application development.

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

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

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

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

Course Introduction

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

CLO No.	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Capabilities of humans and computers that can be utilized while designing interactive systems.	C	1 (Remember)
CLO-2	Understand the process of interaction and causes of problems during interactions and the process of designing interactive systems.	C	2(Understand)
CLO-3	Awareness and application of design principles for improved user experience.	C	3(Apply)
CLO-4	Awareness of different evaluation techniques to evaluate designs.	C	3(Apply)

Course Outline

Introduction to the field of HCI, The Human Factor, The Computer Factor, The Interaction,

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

Reference Material

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

1. Dix, Alan. Human-Computer Interaction. Pearson Education, 2004.
2. Rogers, Yvonne, et al. Interaction Design: Beyond Human-Computer Interaction. 6th Edition, John Wiley & Sons, 2023.

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

Course Introduction

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

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

Course Outline:

Computer Architecture and Importance for Computer Science Graduates, Instruction Set Architectures(ISA), Complex Instruction Set Computing (CISC), Reduced Instruction Set Computing (RISC), Operations of the Computer Hardware, Assembly Language, Registers, Data and Instruction Representation, Different Types of Instructions, Loops and IF Statements in Assembly, Supporting Procedures/Functions in Computer Hardware, Supporting Different Data Types in Hardware, Immediate and Addresses in Instructions, Compiling and Linking Processes to Convert a C/Java Program into Assembly and Converting that into Machine Code, Review of Number Systems, Signed and Unsigned Data Types, Arithmetic Operations (Subtraction, Multiplication, Division) in Hardware, Float Data Types and Arithmetic Operations on Float, Evaluating Performance of a System, Latency, Response Time, and Throughput, CPU Execution Time, Calculating CPU Execution Time for a Program, Benchmarks and Amdahl's Law, Processor Design, Building a 32-bit ALU, Processor Data path, Designing a Processor to Execute Instructions and Include Control Unit, Pipelining and Hazards in Pipelining and Solutions, Memory Hierarchy, Caches, Measuring and Improving Cache Performance, Direct Mapped Cache, Fully Associative Caches and Cache Optimizations, Virtual Memory, Virtual Machines. Storage and other I/O topics, Multiprocessors, Multi-cores and Clusters.

Reference Material

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

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

Course Name	Compiler Construction
Course Code	CS326
Course Area	Domain Core
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Theory of Automata

Course Introduction

The course is intended to teach the students basic techniques & practices of compiler construction. The course will introduce the theory and tools that can be employed to perform syntax-directed translation of a high-level programming language into an executable code. In addition to the exposition of techniques for compilation, the course will also discuss various aspects of the run-time environment into which the high-level code is translated. This will provide insights into semantics aspects of programming languages (e.g., recursion, dynamic memory allocation, types & inferences, object orientation, concurrency & multi-threading).

CLO No.	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	Understand programming language concepts, phases of compilation and translation and execution of high-level language programs.	C	2 (Understand)
CLO-2	Analyze & evaluate the compilation and transformation techniques used by the translation software.	C	4 (Analyze) & 5 (Evaluation)
CLO-3	Apply the knowledge of compiler concepts in developing application and translator software.	C	3 (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 Material

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

1. Watson, Des. A practical approach to compiler construction. Vol. 254. Springer, 2017.
2. Mogensen, Torben Ægidius. Introduction to Compiler Design. Springer Nature, 2024.
3. Dave, Parag H., and Himanshu B. Dave. Compilers: principles and practice. Pearson Education India, 2012.
4. Puntambekar, Anuradha A. Principles of Compiler Design. Technical Publications, 2009.
5. Cooper, Keith D, and Linda Torczon. Engineering a Compiler. San Francisco, California. Morgan Kaufmann, 2004.

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

Course Introduction

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

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

Course Outline

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

Reference Material

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

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

9.3 Domain Elective Courses

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

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

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

Course Outline:

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

Reference Material:

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

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

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

Course Introduction

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

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

Course Outline

Java Platform, Java Virtual Machine and Portability, Classes and Object Creation in Java, OOP Concepts in Java, Data Encapsulation and Abstraction, Inheritance and Polymorphism, Abstract Classes and Interfaces in Java, Java Packages, Inner Classes and Usage, Accessing Private Members, Java Collections and Generics , Exception Handling and Importance, Throwing and Catching Exceptions, try-catch-finally Blocks, Threads and Importance,

Creating Threads, Starting Threads, Seep, Join, Priority, Daemon Threads, Thread Synchronization and Importance, Sharing Objects Between Threads and Race Conditions, Synchronized Methods and Synchronized Blocks, wait(), notify(), notifyall(), Explicit Locks for Synchronization, features in the Java Concurrent Package, Reading and Writing String Values from a File, Preserving Object State using Serialization, Network Programming, Java Sockets and the java.net package, TCP Based Programming, UDP Based Programming, Sending Objects Over the Network Using Serialization, Java Remote Method Invocation (RMI), Graphical User Interfaces (GUIs), Event Driven Programming and using it with GUIs, Java Database Connectivity (JDBC),Functional Programming and Importance, Lambdas, Data Streams in Java.

Reference Material

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

1. Deitel, Paul J, and Harvey M Deitel. Java : How to Program. New York, Pearson, 2019.
2. Schildt, Herbert. Java: A Beginner's Guide, Ninth Edition, 9th Edition. New York, McGraw-Hill, 2022.
3. Schildt, Herbert. Java: The Complete Reference, 12th Edition. McGraw Hill Professional, 2021.

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

Course Introduction

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

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

Course Outline

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

Reference Material

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

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

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	Apply preprocessing techniques on any given raw data.	C	3 (Apply)
CLO-2	Select and apply proper data mining algorithm to discover interesting patterns.	C	2 (Understand)

| **CLO-3** | Analyze and extract patterns to solve problems and point out how to deploy solution. | C | 4 (Analyze) |
| **CLO-4** | Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy. | C | 5 (Evaluate) |

Course Outline

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

Reference Material

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

1. Han, Jiawei, et al. Data Mining: Concepts and Techniques. Burlington, Ma, Elsevier, 2022.
2. Pang-Ning Tan, et al. Introduction to Data Mining. San Francisco, Pearson Education, 2006.
3. Aggarwal, Charu C. Data Mining. Springer, 2015.
4. Hand, David J, et al. Principles of Data Mining. Cambridge, Mass., MIT Press, 2001.

Course Name	**Object Oriented Analysis and Design**
Course Code	CS324
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
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's Taxonomy	
		Domain	Level
CLO-1	To learn aspects of Object-oriented analysis and design.	C	2 (Understand)
CLO-2	To be able to analyze complex computing/ real world problems using object-oriented principles.	C	4 (Analyze)
CLO-3	To be able to design computing/real world problems as object-oriented problems using object-oriented techniques.	C	6 (Create)

Course Outline

Principles of Object Technology. OOP Review. Principles of Modeling. Concept of static, dynamic and functional model, UML modeling and diagrams, OOA&D Overview. OO Development Process. Requirements Engineering, Analysis, and Specification, OO Requirements Engineering Concepts, Use Cases, Prototyping, Class Models. Interaction Diagrams. Architectural and Detailed Design. Class Diagrams. Interaction Diagrams. State Machines and Diagrams. Implementation, Package Diagrams. Activity Diagrams. OO Patterns, Object Oriented Design (OOD), Principles of OOD, SOLID (Single-responsibility Principle, Open-Closed Principle, Liskov Substitution Principle, Interface Segregation Principle, Dependency Inversion Principle), Designing Data Model (ERD), Relationships and associations. Mapping Concepts, O/R Mapping, Shadow information and Scaffolding, Mapping metadata, Mapping inheritance, Mapping object relationships, Mapping relational database relationships.

Reference Material

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

1. Larman, Craig. Applying UML and Patterns: An Introduction to Object Oriented Analysis and Design and 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	Mobile Application Development
Course Code	CS341

Course Area　　　　　Domain Electives
Credit Hours　　　　　3 (2-3)
Contact Hours　　　　　2-3
Pre-requisites　　　　　Advanced Programming

Course Introduction

This course introduces mobile applications programming. The goal of this course is to teach and train students how to design, implement, test, debug and publish smartphone applications on smartphone platforms, especially Android. Students will learn how to take their innovative ideas from conception to the apps market through a series of rigorous hands-on programming assignments and group projects. This is an introductory course aimed at undergraduate students, who have object-oriented programming experience. However, there is a significant amount of programming in this course requiring a commitment on the part of the student. A key part of this course is group projects where students will work in small teams for joint problem solving.

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	Understand aspects of mobile applications programming and uniqueness from programming for other platforms.	C	2 (Understand) & 4 (Analyze)
CLO-2	Understand mobile applications development for the Android operating system that use basic and advanced phone features.	C	2 (Understand)
CLO-3	Design, implement, test, debug and publish smartphone applications.	C	3 (Apply)
CLO-4	Create innovative and robust mobile applications that will be valuable addition to their programming portfolio.	C	6 (Create)

Course Outline

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

Reference Material

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

1. Horton, John. Android programming for beginners. Packt Publishing Ltd, 2015.
2. Phillips, Bill, and Brian Hardy. Android programming: the big nerd ranch guide. Pearson Education, 2013.
3. Wei-Meng, Lee. "Beginning Android™ 4 Application Development." (2012).

4. Meier, Reto. Professional Android 4 application development. John Wiley & Sons, 2012.

Course Name	Cyber Security
Course Code	CS303
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Information Security

Course Introduction

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

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

Course Outline

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

Reference Material

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

1. Easttom, Chuck. Computer security fundamentals. Pearson IT certification, 2019.

2. Ciampa, Mark D. Security+ Guide to Network Security Fundamentals. Boston, Mass., Course Technology Cengage Learning, 2012.
3. Pfleeger, Charles P, et al. Security in Computing. Hoboken, Pearson Education, 2015.

Course Name	Advanced Mobile Application Development
Course Code	CS410
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Mobile Application Development

Course Introduction

This course is a continuation of Mobile Application Development (CS341). 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's Taxonomy	
		Domain	Level
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.	C	2 (Understand)
CLO-2	Apply the principles, and methods of cross-platform tools to develop interactive mobile applications.	C	3 (Apply)
CLO-3	Test cross-platform mobile applications.	C	5 (Evaluation)

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 Material

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

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	Cloud Computing
Course Code	CS417
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	None

Course Introduction

Cloud computing provides huge computation and storage resources on demand and exciting most individuals and businesses. Large user-base is attracted to use cloud computing mainly due to pay-per-usage and on-demand resource provisioning characteristics. However, cloud computing systems are developed using distributed computing concepts and algorithms. In this course, you will learn tools, techniques, algorithms, and systems related to cloud computing theoretically and practically.

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	**Level**
CLO-1	Understanding basic concepts of distributed systems and cloud computing technologies.	C	2 (Understand)
CLO-2	Understanding of virtualization and its various flavors.	C	2 (Understand)
CLO-3	Ability to address large scale data processing challenges.	C	3 (Apply)

Course Outline

Introduction to Cloud Computing History and Background of Cloud Computing, Virtualization, Essential Characteristics of Cloud Computing, Benefits of Cloud Computing, Risks and Challenges of Cloud Computing, Roles and Boundaries of Cloud Computing, Cloud

Service Models Data Storage in Clouds Miscellaneous Services of Cloud Computing Cloud Deployment Models, Service Oriented Architecture, Cloud Security Threats, Trust Issues in Cloud, Mechanisms Related to Cloud Infrastructure, Service Agreements, Cloud Hosting Data Center Design, Cloud Architecture, Specialized Cloud Mechanisms, Cloud Management, Fundamental Cloud Architectures, Advanced Cloud Architectures, Cloud Federation, Cloud Delivery/Service Models' Perspectives, Inter-Cloud Resource Management, Cloud Cost Metrics and Pricing Models, Cloud Service Quality Metrics, Cloud Simulator, Computer Security Basics, Network Security Basics, Cloud Security Mechanisms, Privacy Issues of Cloud Computing, Security Issues of Cloud Computing, Trust Issues of Cloud Computing, Open Issues in Cloud, Disaster Recovery in Cloud Computing, Migrating to the Cloud, Cloud Application Scalability and Resource Scheduling, Mobile Cloud Computing, Special Topics in Cloud Computing

Reference Material

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

1. Erl, Thomas, Ricardo Puttini, and Zaigham Mahmood. Cloud computing: concepts, technology & architecture. Pearson Education, 2013.
2. Kris Jamsa. Cloud Computing. Jones & Bartlett Publishers, 2013.
3. Liu, Fang, et al. "NIST cloud computing reference architecture." NIST special publication, (2011).

Course Name	Web Engineering
Course Code	CS349
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Web Technologies

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Understand concepts, principles & methods of Web engineering.	C	2 (Understand)
CLO-2	Apply the principles, and methods of Web engineering to Web applications development.	C	3 (Apply)

| **CLO-3** | Analyze and design comprehensive systems for the creation, dissemination, storage, retrieval, and use of electronic records and documents. | C | 4 (Analyze) |
| **CLO-4** | Learn techniques and evaluation metrics for ensuring the proper operability, maintenance and security of a web application. | C | 2 (Understand) & 5 (Evaluation) |

Course Outline

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

Reference Material

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

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

Course Name	**Software Testing and Quality Assurance**
Course Code	CS421
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Programming Fundamentals, Software Engineering

Course Introduction

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

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

Course Outline

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

Reference Material

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

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

Course Name	Natural Language Processing
Course Code	CS420
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Artificial Intelligence

Course Introduction

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

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

Course Outline

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

Reference Material

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

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

Course Name	Digital Image Processing
Course Code	CS353
Course Area	Domain Electives
Credit Hours	3 (2-3)
Contact Hours	2-3
Pre-requisites	Calculus and Analytical Geometry, Applied 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's Taxonomy	
		Domain	Level
CLO-1	Understanding of the issues involved in image processing and the approaches, algorithms, and tools used to solve them.	C	2 (Understand)
CLO-2	Able to compare and evaluate different approaches, and think about alternate solutions.	C	4 (Analyze) & 5 (Evaluate)
CLO-3	Apply existing techniques to practical problems and undertake an undergrad level project in the area of image processing.	C	3 (Apply)

Course Outline

Introduction to Digital Image Processing (DIP); Fundamentals of Digital Image: visual perception, light and 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 Material

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

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	Introduction to Data Science
Course Code	CS306
Course Area	Domain Core
Credit Hours	4 (3-3)

Contact Hours   3-3
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 Outcome	Bloom's Taxonomy	
		Domain	Level
CLO-1	Describe what Data Science is and the skill sets needed to be a data scientist.	C	2 (Understand)
CLO-2	Apply EDA and the Data Science process in a case study.	C	3 (Apply)
CLO-3	Comprehend the fundamental constructs of Python programming language.	C	2 (Understand)
CLO-4	Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C	3 (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 Material

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

1. Blum, Avrim, John Hopcroft, and Ravindran Kannan. Foundations of Data Science. Vorabversion eines Lehrbuchs, 2016.
2. Saltz, Jeffrey S., and Jeffrey M. Stanton. An Introduction to Data Science. 1st Edition, SAGE Publications, 2017.
3. Severance, Charles R. Python for Everybody: Exploring Data Using Python 3. 1st Edition, CreateSpace Independent Publishing Platform, 2016.
4. O'Neil, Cathy, and Rachel Schutt. Doing Data Science: Straight Talk from the Frontline. 1st Edition, O'Reilly Media, 2014.
5. EMC Education Services. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data. 1st Edition, John Wiley & Sons, 2015.

Course Name	Data Warehousing and Business Intelligence
Course Code	CS330
Course Area	Domain Elective
Contact Hours	2-3
Pre-requisites	Introduction to Data Science

Course Introduction

Gives an overview about importance & significance of Data Warehousing (DWH) and Business Intelligence (BI). Discusses the main concepts and solutions for DWH and BI. The key concepts underpinning the logical design, physical design and implementation of data warehouses are appraised. Data collection, data extraction, cleansing, transformation and loading methods are considered along with query optimization techniques. Differentiation between OLAP & OLTP. Data Warehousing supports information processing by providing a solid platform of integrated, historical, and consistent data for performing enterprise- wide data analysis.

CLO No	Course Learning Outcome	Bloom's Taxonomy Domain	Level
CLO-1	Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process.	C	2 (Understand)
CLO-2	Demonstrate an understanding of the fundamental concepts of the Star and the Snowflake Schema; learn how to design the schema of a DW based on these two models.	C	2 (Understand)
CLO-3	Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas.	C	3 (Apply)
		C	3 (Apply)

Course Outline

Introduction to Data Warehouse and Business Intelligence; Necessities and essentials of Business Intelligence; DW Life Cycle and Basic Architecture; DW Architecture in SQL Server;

Logical Model; Indexes; Physical Model; Optimizations; OLAP Operations, Queries and Query Optimization; Building the DW; Data visualization and reporting based on Datawarehouse using SSAS and Tableau; Data visualization and reporting based on Cube; Reports and Dashboard management on PowerBI; Dashboard Enrichment; Business Intelligence Tools.

Reference Material

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

1. Inmon, William H. Building the data warehouse. 4th Edition. John Wiley & Sons, 2005.
2. Kimball, Ralph. The Data Warehouse Toolkit, 3rd Edition. Wiley, 2013.
3. Golfarelli, Matteo, and Stefano Rizzi. Data warehouse design: Modern principles and methodologies. 1st Edition. McGraw-Hill, Inc., 2009.

9.4 Mathematics and Supporting Courses

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	Measures of central tendency and variation.	C	1 (Remember)
CLO-2	The concept of a sets, probability, random variables and probability distribution.	C	2 (Understand)
CLO-3	Statistical inference, regression and correlation.	C	4 (Analyze)

Course Outline

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear, Combinations of Random Variables, Chebyshev's Theorem. Discrete, Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions,

Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, F-Quantile and Probability Plots, Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Square Estimators.

Reference Material

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

1. Walpole, Ronald E., Raymond H. Myers, Raymond H. Myers, Raymond H. Myers, Probability and statistics for engineers and scientists. 9th Edition., Pearson, 2011.
2. Hayter, Anthony J. "Probability and statistics for engineers and scientists. 4th Edition., Cengage Learning 2012.
3. Spiegel, Murray R., R. Alu Srinivasan, and John J. Schiller. Schaum's outline of probability and statistics, 4th Edition., McGraw Hill, 2012.
4. Haigh, John. Probability: A very short introduction. Vol. 310. Oxford University Press, 2012.

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO-1	Understand multivariable functions.	C	2 (Understand)
CLO-2	Compute multivariable integrals.	C	5 (Evaluate)
CLO-3	Analyze vector fields and line integrals.	C	4 (Analyze)

Course Outline

Calculus of parametric curves, polar coordinates, coordinates and vectors in three-dimensions, dot and cross products, lines and planes in three-dimensions, conic sections and quadratic surfaces, parametric curves in three-dimensions, functions of two and three variables, partial

derivatives, tangent planes and differentiability, the chain rule, the gradient and directional derivatives, maxima and minima, Lagrange multipliers, double integrals over rectangles and general regions, double integrals in polar coordinates, applications of double integrals, surface area as double integral, triple integral, cylindrical and spherical coordinates, vector fields and line integrals, Greens theorem, divergence and curl, Stokes theorem, divergence theorem.

Reference Material

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

1. Stewart, James, Daniel K. Clegg, Saleem Watson, Multivariable Calculus, 9th Edition., Centage Learning, 2012.
2. Briggs, William, Lyle Cochran, Bernard Gillett, Eric Schulz, Multivariable Calculus, 3rd Edition., Pearson, 2018.
3. Dineen, Seán. Multivariate calculus and geometry, 3rd Edition., Springer-Verlag London, 2014.

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

Course Introduction

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

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

Course Outline

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

Factorization of the DFT. Matrix. Fast Fourier Transforms. The Discrete Time Fourier Transform.

Reference Material

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

1. Strang, Gilbert. Introduction to linear algebra. 5th Edition., Wellesley-Cambridge Press, 2022.
2. Poole, David. Linear algebra: A modern introduction. 4th Edition.,Cengage Learning, (2015.
3. Kolman, Bernard, and David Hill. Elementary Linear Algebra with Applications. 9th Edition., Pearson, 2014.
4. Strang, Gilbert, and Betsy Coonley. Linear Algebra and Its Applications. 4th Edition., Brooks/Cole, 2005
5. Anton, Howard, Irl Bivens, and Chris Davis. Elementary Linear Algebra: Applications Version. 12th Edition., Wiley, 2020.

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

Course Introduction

Students in the senior level needs good technical writing skills not only for writing project report but also useful for them to communicate their resume and get place in the market. This is a high level course which provide useful knowledge to the students for writing proposals etc. Further, the course aims at augmenting students' proficiency in technical writing in order to sensitize them to the dynamics, challenges, and needs of the modern world characterized by technologically advanced social, cultural, and corporate settings. It will focus on students' ability to effectively convey and exchange information in cross-cultural, international, and multinational milieu necessitated by the emergence of global society.

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

Course Outline

Overview of Technical Reporting, use of Library and Information Gathering, Administering Questionnaires, Reviewing the Gathered Information, Technical Exposition, Topical Arrangement, Exemplification, Definition, Classification and Division, Casual Analysis, Effective Exposition, Technical Narration, Description and Argumentation, Persuasive Strategy, Organizing Information and Generation Solution: Brainstorming, Organizing Material, Construction of the Formal Outline, Outlining Conventions, Electronic Communication, Generation Solutions, Polishing Style, Paragraphs, Listening Sentence Structure, Clarity, Length and Order, Pomposity, Empty Words, Pompous Vocabulary, Document Design: Document Structure, Preamble, Summaries, Abstracts, Table of Contents, Footnotes, Glossaries, Cross-Referencing, Plagiarism, Citation and Bibliography, Glossaries, Index, Appendices, Typesetting Systems, Creating the Professional Report; Elements, Mechanical Elements and Graphical Elements, Reports Proposals, Progress Reports, Articles, Research Papers, Feasibility Reports, Project Reports, Technical Research Reports, Manuals and Documentation, Thesis. Electronic Documents, Writing Hypotheses, Questions and Evidence, Describing Mathematics, Describing Algorithms, Explaining Graphs, Figures, and Tables, Discussing Experimentation, Writing a Paper, Presentations , Introduction to Latex, Introduction to Popular Reference Management Tools such as EndNote, Mendeley.

Reference Material

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

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

9.5   Elective Supporting Courses

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

Course Introduction

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

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

Course Outline:

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

Reference Material

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

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

9.6 General Education Courses

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Understand basics of computing technology (software hardware and computer networks).	C	2 (Understand)
CLO-2	Understand number systems conversions and arithmetic.	C	2 (Understand)

CLO-3	Have knowledge of types of software and computing related technologies.	C	2 (Understand)
CLO-4	Apply knowledge of software and computing related technologies.	C	3 (Apply)

Course Outline

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

Reference Material

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

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

Course Name	Functional English
Course Code	
Course Area	General Education
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	None

Course Introduction

This is first course in English to the Bachelor of Science students and covers all the fundamental concept of English composition and comprehension. The course is designed in such a way that students can use this knowledge to further enhance their language skills in English. The course aims at enhancing students' skill and competence in communicating their ideas in writing and speaking in English language. It will primarily focus on four areas of language to help the students achieve proficiency in language use, develop skills in listening comprehension, improve reading efficiency, use the conventions of standard written English with skill and assertion, build-up vocabulary, and clearly and accurately reproduce specific data. It will illustrate the force and effectiveness of simple and direct English.

CLO No	Course Learning Outcomes	Bloom's Taxonomy	
		Domain	Level
CLO 1	Essay writing and sentence errors.	C	1 (Remember)
CLO 2	Deliver oral presentations.	C	3 (Apply)
CLO 3	Narration and reviewing.	C	5 (Evaluate)

Course Outlines

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

Reference Material

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

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

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

Course Introduction

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

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

Course Outline

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

Reference Material

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

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

Course Name	Discrete Structures
Course Code	CS120
Course Area	General Education
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	None

Course Introduction

Introduces the foundations of discrete mathematics as they apply to Computer Science, focusing on providing a solid theoretical foundation for further work. Further, this course aims to develop understanding and appreciation of the finite nature inherent in most Computer Science problems and structures through study of combinatorial reasoning, abstract algebra, iterative procedures, predicate calculus, tree and graph structures. In this course more emphasis shall be given to statistical and probabilistic formulation with respect to computing aspects.

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

Course Outline

Mathematical reasoning, propositional and predicate logic, rules of inference, proof by induction, proof by contraposition, proof by contradiction, proof by implication, set theory, relations, equivalence relations and partitions, partial orderings, recurrence relations, functions, mappings, function composition, inverse functions, recursive functions, Number Theory, sequences, series, counting, inclusion and exclusion principle, pigeonhole principle, permutations and combinations. Algorithms, Searching and Sorting Algorithms, elements of graph theory, planar graphs, graph coloring, Graph Algorithms, euler graph, Hamiltonian path, rooted trees, traversals.

Reference Material

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

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

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Techniques of funding limits, Indeterminate forms of limits, continuous and discontinuous functions and their applications.	C	1 (Remember)
CLO-2	Differentiation, geometrical and physical meaning of derivatives.	C	2 (Understand)
CLO-3	Concept and idea of integration.	C	2 (Understand)
CLO-4	Applications of integration; area under the curve, analytical geometry.	C	3 (Apply)

Course Outline

Real Numbers and the Real Line, Coordinates, Lines, and Increments, Functions, Shifting Graphs, Trigonometric Functions. Limits and Continuity: Rates of Change and Limits, Rules for Finding Limits, Target Values and Formal Definitions of Limits, Extensions of the Limit Concept, Continuity, Tangent Lines. Derivatives: The Derivative of a Function, Differentiation Rules, Rates of Change, Derivatives of Trigonometric Functions, The Chain Rule, Implicit Differentiation and Rational Exponents, Applications of Derivatives. Integration: Indefinite

Integrals, Integration by Substitution, Definite Integrals, Substitution in Definite Integrals, Numerical Integration, Applications of Integrals, Transcendental Functions: Inverse Functions and Their Derivatives, Natural Logarithms, The Exponential Function, ax and logax, Growth and Decay, L'Hôpital's Rule, Relative Rates of Growth, Inverse Trigonomic Functions, Derivatives of Inverse Trigonometric Functions; Hyperbolic Functions. Conic Sections, Parameterized Curves, and Polar Coordinates, Graphing in Polar Coordinates, Polar, Equations for Conic Sections, Integration in Polar Coordinates. Vectors and Analytic Geometry in Space, Vectors in the Plane Dot Products, Vector-Valued Function Cartesian (Rectangular) Coordinates and Vectors in Space, Dot Products, Cross Products, Lines and Planes in Space Cylinders and Quadric Surfaces, Cylindrical and Spherical Coordinates.

Reference Material

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

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

Course Name	Islamic Studies
Course Code	
Course Area	General Education
Credit Hours	2 (2-0)
Contact Hours	2-0
Pre-requisites	None

Course Introduction

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

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

other religions.

Course Outline

Basic Themes of Quran, Introduction to Sciences of Hadith, Introduction to Islamic Jurisprudence, Primary & Secondary Sources of Islamic Law, Makken & Madnian life of the Prophet, Islamic Economic System, Political theories, Social System of Islam. Definition of Akhlaq. The Most Important Characters mentioned in the Holy Qur'an and Sunnah, SIDQ (Truthfulness) Generosity Tawakkaul(trust on Allah)Patience Taqua (piety).Haqooq ul ibad in the light of Quran & Hadith - the important characteristic of Islamic Society.

Reference Material

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

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

Course Name	Ideology and Constitution of Pakistan
Course Code	
Course Area	General Education
Credit Hours	2 (2-0)
Contact Hours	2-0
Pre-requisites	None

Course Introduction

Pakistan studies is an important course at this university in which students study about their motherland. The following are the specific objective of the course

- To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan.
- To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

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

Course Outline

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

Reference Material

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

1. Chaudhury, M. The Emergence of Pakistan. 1967.
2. Aziz, K. The Making of Pakistan. 1976.
3. Rabbani, Muhammad Ikram. A Comprehensive Book of Pakistan Studies. 3rd Edition., The Caravan Press, 2001.

Course Name	Entrepreneurship
Course Code	BA565
Course Area	General Education
Credit Hours	2 (2-0)
Contact Hours	2-0
Pre-requisites	None

Course Introduction

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

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

CLO-3	Identify the critical concepts of business planning and increase chances of business success.	C	2 (Understand)
CLO-4	Discuss examples of current entrepreneurs.	C	4 (Analyze)

Course Outline

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

Reference Material

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

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

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

Course Introduction:

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

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

Course Outline

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

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

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

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

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

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

7. Diversity, Inclusion and Social Justice
- Understanding diversity in society (ethnic, cultural, economic, political etc.).
- Youth, women and minorities' engagement in social development.
- Addressing social inequalities and injustices in Pakistan.

- Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

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

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

Reference Material:

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

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

9.6.1   Arts & Humanities Course

Course Name	Professional Practices
Course Code	CS423
Course Area	General Education
Credit Hours	3 (3-0)
Contact Hours	3-0
Pre-requisites	None

Course Introduction

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

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

Course Outline

Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology); Definitions of Computing (software engineering, Computer Science, Information Technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities, software related contracts, Software house organization. Intellectual Property Rights, The Framework of Employee Relations Law and Changing ManagementPractices, 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. Accountabilityand Auditing, Social Application of Ethics.

Reference Material

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

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

5. Beabout, Gregory R. Applied Professional Ethics. University Press of America, 1993.

9.6.2   Natural Sciences Course

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

Course Introduction

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

CLO No	Course Learning Outcomes	Bloom's Taxonomy Domain	Level
CLO-1	Comprehend the working knowledge of fundamental laws of physics.	C	2(Understand)
CLO-2	Apply the knowledge of fundamental laws to solve various real world problems.	C	3(Apply)
CLO-3	Analyze different physical problems using the knowledge gained from different areas like electromagnetism, optics etc.	C	4(Analyze)

Course Outline

Electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charge isolated conductor, Electric potential energy, Electric potentials, Calculating the potential from the field and related problem Potential due to point and continuous charge distribution, Potential due to dipole, equipotential surfaces, Calculating the field from the potential, Electric current, Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot- Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroids, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf, Induced electric field, Induced electric fields, The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total

internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.

Reference Material

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

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