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		
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.

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

				• 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

				• 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)

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	Bloom's Taxonomy 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 storageand 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 schemasusing different data models.	C	6 (Create)
CLO-3	Understand and identify functional dependencies and resolve databaseanomalies by normalizing database tables.	C	2 (Understand)
CLO-4	Understand and use Structured Query Language (SQL) for databasedefinition 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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 thefundamental concept of English composition and comprehension. The course is designed in such a way that students can use this knowledge to further enhance theirlanguage skills in English. The course aims at enhancing students' skill andcompetence in communicating their ideas in writing and speaking in Englishlanguage. 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; Howto 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	Bloom's Taxonomy 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	Bloom's Taxonomy 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.

BS (CS)

Old Course Outline

Proposed Revised Scheme of Studies for BS (CS)

Semester I		
CS3101	Fundamentals of Computers	3(2+1)
CS3102	Calculus and Analytical Geometry	3(3+0)
CS3103	Probability and Statistics	3(3+0)
CS3104	Functional English	3(3+0)
CS310	Programming	4(3+1

Semester II		
CS3201	Multivariate Calculus	3(3+0)
CS3202	Discrete Structures	3(3+0)
CS3203	Pakistan Studies/ Islamic Studies	3(3+0)
CS3204	Object Oriented Programming	4(3+1)
CS320	Digital Logic Design	3(2+1

Semester III		
MATH-432	Computation in MATLAB	3(2+1)
CS4301	Data Structures and Algorithms	4(3+1)
CS4302	Communication Skills	3(3+0)
CS4303	Data Communication	3(3+0)
CS430	Linear Algebra	3(3+0

Semester IV		
CS4401	Database Systems	4(3+1)
CS4402	Operating Systems	4(3+1)
CS4403	Computer Networks	3(3+0)
CS4404	Theory of Automata	3(3+0)
CS440	Web Technologies	4(3+1

Semester V		
CS5501	Design and Analysis of Algorithms	3(3+0)
CS5502	Object Oriented Analysis and Design	3(2+1)
CS5503	Advanced Programming	4(3+1)
CS5504	Information Security	3(3+0)
BES-	Geographic Information	3(3+0

Semester VI		
CS5601	Computer Organization and Architecture	4(4+0)
CS5602	Software Engineering	3(3+0)
CS5603	Mobile Applications Development	4(3+1)
CS5604	Human Computer Interaction	3(3+0)
CS5605	Applied Image Processing	3(2+1

Semester VII		
CS6701	Technical and Scientific Writing	3(3+0)
CS6702	FYP - I	3(0+3)
BA565	Entrepreneurship	3(3+0)
CS67XX	Specialization Elective - I	3(3+0)
CS67XX	Specialization Elective - II	3(3+0

Semester VIII		
CS6801	Natural Language Processing	3(3+0)
CS6802	Professional Practices	3(3+0)
CS6803	FYP - II	3(0+3)
CS68XX	Specialization Elective - III	3(3+0)
CS68XX	Specialization Elective - IV	3(3+0

Total Credit Hours = 132

Distribution of Courses According to HEC Framework

1. Computing - CS Core Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
1	CS3105	-	Programming Fundamentals	4(3+1)	1
2	CS3204	1	Object Oriented Programming	4(3+1)	2
4	CS3205	-	Digital Logic Design	3(2+1)	2
5	CS3202	18, 34	Discrete Structures	3(3+0)	2
6	CS4301	1	Data Structures and Algorithms	4(3+1)	3
7	CS4303	-	Data Communication	3(3+0)	3
8	CS4401	21	Database Systems	4(3+1)	4
9	CS4402	1, 6	Operating Systems	4(3+1)	4
10	CS4403	7	Computer Networks	3(3+0)	4
11	CS4405	21, 2	Web Technologies	4(3+1)	4
12	CS5502	2	Object Oriented Analysis and Design	3(2+1)	5
13	CS5503	2, 9	Advanced Programming	4(3+1)	5
14	CS5602	12	Software Engineering	3(3+0)	6
15	CS5603	1, 2	Mobile Applications Development	4(3+1)	6
16	CS5604	21, 1	Human Computer Interaction	3(3+0)	6
17	CS6702 & CS6803	13	Final Year Project (I & II)	(0+ 3) + (0+3)	7 and 8
Total Credit Hours				**59**	

2. Computing - Supporting Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
18	CS3102	-	Calculus and Analytical Geometry	3(3+0)	1
19	CS3103	-	Probability and Statistics	3(3+0)	1
20	CS4304	-	Linear Algebra	3(3+0)	3
Total Credit Hours				**9**	

3. Computing - General Education Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
21	CS3101	-	Fundamentals of Computers	3(2+1)	1
22	CS3104	-	Functional English	3(3+0)	1
23	CS3203	-	Pakistan Studies/Islamic Studies	3(3+0)	2
24	CS4302	22	Communication Skills	3(3+0)	3
25	CS6701	-	Technical and Scientific Writings	3(3+0)	7
26	CS6802	-	Professional Practices	3(3+0)	8
Total Credit Hours				**18**	

4. Computer Science - Core Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
27	CS5504	2, 8, 10, 11	Information Security	3(3+0)	5
28	CS4404	1, 5, 6	Theory of Automata	3(3+0)	4
29	CS4305	5	Artificial Intelligence	3(3+0)	3

30	CS5501	1, 6	Design and Analysis of Algorithms	3(3+0)	5
31	CS5601	4	Computer Organization and Architecture	4(4+0)	6
32	CS5605	-	Applied Image Processing	3(2+1)	6
33	CS6801	1, 29	Natural Language Processing	3(3+0)	8
Total Credit Hours				**22**	

5. Computer Science - Supporting & University Elective Courses

#	Code	Pre Req.	Course Title	Credit Hours	Semester
34	CS3201	18	Multivariate Calculus	3(3+0)	2
35	MATH-432	2	Computation in MATLAB	3(2+1)	3
36	BES-475	-	Geographic Information System	3(3+0)	5
37	BA565	-	Entrepreneurship	3(3+0)	7
Total Credit Hours				**12**	

6. 7th Semester Specializations Elective Courses

Please use the following abbreviations for specializations:

GT - General Track

WE - Web Engineering

CN - Computer Networks

DS - Database Systems

SE - Software Engineering

PR - Pattern Recognition

#	Course Code	Pre Req.	Course Title	Credit Hours	GT	WE	CN	DS	SE	PR
38	CS6703	1, 28	Compiler Construction	3(3+0)	✓					
39	CS6704	21, 11	E-Commerce Technologies & Applications	3(3+0)	✓	✓				
40	CS6705	29	Expert Systems	3(3+0)	✓			✓		
41	CS6706	13, 31	Introduction to Parallel Computing	3(3+0)	✓					
42	CS6721	11	Information Architecture	3(3+0)	✓	✓		✓	✓	
43	CS6722	11	Web Content Management Systems	3(2+1)	✓	✓		✓	✓	
44	CS6723	11, 13, 14	Web Engineering	3(3+0)	✓	✓			✓	
45	CS6731	10	Routing and Switching	3(3+0)	✓		✓			
46	CS6732	1, 10	Internet of Things(IoT)	3(3+0)	✓		✓			
47	CS6733	10, 13	Network Programming	3(3+0)	✓		✓			
48	CS6734	10	Wireless and Mobile Networks	3(3+0)	✓		✓			
49	CS6741	8	Advanced Database Systems	3(3+0)	✓			✓	✓	

50	CS6742	8	Fundamentals of Data Warehousing	3(3+0)	✓			✓		
51	CS6751	-	Usability Engineering	3(3+0)	✓	✓			✓	
52	CS6752	13, 14	Computer Aided Software Engineering	3(3+0)	✓				✓	
53	CS6753	14	Software Architecture and Design	3(3+0)	✓	✓			✓	
54	CS6761	6, 29	Natural Computation	3(3+0)	✓			✓		✓
55	CS6762	6, 13, 18, 19, 20	Introduction to Neural Networks	3(3+0)	✓			✓		✓

7. 8th Semester Specializations Elective Courses

Please use the following abbreviations for specializations:

GT - General Track

WE - Web Engineering

CN - Computer Networks

DS - Database Systems

SE - Software Engineering

PR - Pattern Recognition

#	Course Code	Pre Req	Course Title	Credit Hours	GT	WE	CN	DS	SE	PR
56	CS6804	2, 20	Computer Graphics and Imaging	3(2+1)	✓					✓
57	CS6805	18, 20, 34	Numerical Computing	3(2+1)	✓					
58	CS6806	18, 20, 29	Digital Image Processing	3(3+0)	✓					✓
59	CS6807	10	Telecommunication Systems	3(3+0)	✓		✓			
60	CS6808	7, 10	Network Security	3(3+0)	✓		✓			
61	CS6809	-	Introduction to Bioinformatics	3(3+0)	✓			✓	✓	
62	CS6810	19	Differential Equations	3(3+0)	✓					
63	CS6821	11,13, 19, 20	Information Retrieval and Web Search	3(3+0)	✓	✓		✓	✓	
64	CS6822	11, 13	Service-Oriented Architecture	3(3+0)	✓	✓			✓	
65	CS6823	15	Wearable Technology	3(3+0)	✓	✓				
66	CS6831	48	Emerging Computer Networks	3(3+0)	✓		✓			

67	CS6832	10	Network Administration	3(3+0)	✓		✓			
68	CS6841	8	Big Data Concepts	3(3+0)	✓	✓		✓	✓	
69	CS6842	8	Database Administration	3(3+0)	✓			✓		
70	CS6843	-	ETL (Extract, Transform, Load) Programming	3(3+0)	✓			✓		
71	CS6851	14	Software Project Management	3(3+0)	✓	✓		✓	✓	
72	CS6852	13, 14	Software Testing	3(3+0)	✓				✓	
73	CS6853	12, 13, 14	Open Source Development	3(3+0)	✓	✓		✓	✓	
74	CS6861	6, 13, 19, 20	Machine Learning	3(3+0)	✓			✓		✓

Revision at a Glance

During revision, the following changes and additions are performed in each of the semester and specializations elective courses.

Semester I			
Course Code	**Course Title**	**Credit Hours**	**Remarks**
CS3101	Fundamentals of Computers	3(2+1)	• Course code is changed • Title is kept same • Contents are changed • Books are updated • Lab is included
CS3102	Calculus and Analytical Geometry	3(3+0)	• New course is added in place of Mathemantics-1 • Course code is changed
CS3103	Probability and Statistics	3(3+0)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3104	Functional English	3(3+0)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3105	Programming Fundamentals	4(3+1)	• Course code is changed • Title is kept same • Contents are changed • Books are updated • Lab is included
Total Semester Credit Hours:		**16**	

Semester II			
Course Code	**New Title**	**Credit Hours**	**Remarks**

CS3201	Multivariate Calculus	3(3+0)	• New course is added in place of Mathemantics-1 • Course code is changed
CS3202	Discrete Structures	3(3+0)	• Course code is changed • Title is changed • Contents are changed • Books are updated
CS3203	Pakistan Studies/Islamic Studies	3(3+0)	• Course code is changed
CS3204	Object Oriented Programming	4(3+1)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS3205	Digital Logic Design	3(2+1)	• Moved from semester III • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		**16**	

Semester III			
Course Code	**New Title**	**Credit Hours**	**Remarks**
MATH-432	Computation in MATLAB	3(2+1)	• New course is added in place of Electronics • Course code is changed • Code from the Department of Mathematics is used
CS4301	Data Structures and Algorithms	4(3+1)	• Course code is changed • Title is changed • Contents are changed • Books are updated • Lab is added
CS4302	Communication Skills	3(3+0)	• Course code is changed • Title is kept same • Contents are kept same

			• Books are updated
CS4303	Data Communication	3(3+0)	• New course is added • New code is used
CS4304	Linear Algebra	3(3+0)	• New course is added • New code is used
CS4305	Artificial Intelligence	3(3+0)	• Moved from semester V • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		**19**	

Semester IV			
Course Code	**New Title**	**Credit Hours**	**Remarks**
CS4401	Database Systems	4(3+1)	• Moved from semester III • Course code is changed • Title is changed • Contents are changed • Books are updated
CS4402	Operating Systems	4(3+1)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS4403	Computer Networks	3(3+0)	• Course code is changed • Title is changed • Contents are changed • Books are updated
CS4404	Theory of Automata	3(3+0)	• Moved from Semester VI • Course code is changed • Title is changed • Contents are changed • Books are updated

CS4405	Web Technologies	4(3+1)	• Course is moved from Semester V • Course code is changed • Title is kept same • Contents are changed • Books are updated
Total Semester Credit Hours:		**18**	

Semester V			
Course Code	**New Title**	**Credit Hours**	**Remarks**
CS5501	Design and Analysis of Algorithms	3(3+0)	• Course code is changed • Title is changed • Contents are changed • Books are updated
CS5502	Object Oriented Analysis and Design	3(2+1)	• New course is added in place of Software Engineering - I • Course code is changed
CS5503	Advanced Programming	4(3+1)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS5504	Information Security	3(3+0)	• New course is added. • New code is used
BES-475	Geographic Information System	3(3+0)	• New course is added in place of Human Resource Management • Course code is changed • Code from the Department of Environmental Science is used
Total Semester Credit Hours:		**16**	

Semester VI

Course Code	New Title	Credit Hours	Remarks
CS5601	Computer Organization and Architecture	4(4+0)	• Course code is changed • Title is changed • Contents are changed • Books are updated
CS5602	Software Engineering	3(3+0)	• New course is added in place of Software Engineering - II • New course code is used
CS5603	Mobile Applications Development	4(3+1)	• Course moved from electives of semester VIII • New course code is used • Title is changed • Contents are changed • Books are updated
CS5604	Human Computer Interaction	3(3+0)	• New course is added • New course code is used
CS5605	Applied Image Processing	3(2+1)	• New course is added • New course code is used
Total Semester Credit Hours:		**17**	

Semester VII			
Course Code	**New Title**	**Credit Hours**	**Remarks**
CS6701	Technical and Scientific Writing	3(3+0)	• New course is added • New code is used
BA565	Entrepreneurship	3(3+0)	• New course is added • Course code is changed • Code from the Department of IM Studies is used
CS6702	FYP-I	3(0+3)	• Course code is changed • Title is changed
CS67XX	Specialization Elective - I	3	• Remarks are shown in the 7th semester specializations elective courses table

CS67XX	Specialization Elective - II	3	• Remarks are shown in the 7th semester specializations elective courses table
Total Semester Credit Hours:		**15**	

Semester VIII			
Course Code	**New Title**	**Credit Hours**	**Remarks**
CS6801	Natural Language Processing	3(3+0)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6802	Professional Practices	3(3+0)	• New course is added • New code is used
CS6803	FYP-II	3(0+3)	• Course code is changed • Title is changed
CS68XX	Specialization Elective - III	3	• Remarks are shown in the 8th semester specializations elective courses table
CS68XX	Specialization Elective - IV	3	• Remarks are shown in the 7th semester specializations elective courses table
tal Semester Credit Hours:		**15**	

7th Semester Specializations Elective Courses			
Course Code	**Course Title**	**Credit Hours**	**Remarks**
CS6703	Compiler Construction	3(3+0)	• Course moved into electives from semester VII • Course code is changed • Content are changed • Books are updated
CS6704	E-Commerce Technologies & Applications	3(3+0)	• Course code is changed • Title is changed • Content are changed

			• Books are updated
CS6705	Expert Systems	3(3+0)	• Course code is changed • Content are changed • Books are updated
CS6706	Introduction to Parallel Computing	3(3+0)	• New course is added • New course code is used
CS6721	Information Architecture	3(3+0)	• New course is added • New course code is used
CS6722	Web Content Management Systems	3(2+1)	• New course is added • New course code is used
CS6723	Web Engineering	3(3+0)	• New course is added • New course code is used
CS6731	Routing and Switching	3(3+0)	• New course is added • New course code is used
CS6732	Internet of Things (IoT)	3(3+0)	• New course is added • New course code is used
CS6733	Network Programming	3(3+0)	• New course is added • New course code is used
CS6734	Wireless and Mobile Networks	3(3+0)	• New course is added • New course code is used
CS6741	Advanced Database Systems	3(3+0)	• New course is added • New course code is used
CS6742	Fundamentals of Data Warehousing	3(3+0)	• New course is added • New course code is used
CS6751	Usability Engineering	3(3+0)	• New course is added • New course code is used
CS6752	Computer Aided Software Engineering	3(3+0)	• New course is added • New course code is used
CS6753	Software Architecture and Design	3(3+0)	• New course is added • New course code is used
CS6761	Natural Computation	3(3+0)	• New course is added • New course code is used
CS6762	Introduction to Neural Networks	3(3+0)	• New course is added • New course code is used

8th Semester Specializations Elective Courses			
Course Code	**Course Title**	**Credit Hours**	**Remarks**
CS6804	Computer Graphics and Imaging	3(2+1)	• Course code is changed • Title is changed • Content are changed • Books are updated
CS6805	Numerical Computing	3(2+1)	• Course moved into electives from semester VI • Course code is changed • Title is changed • Content are changed • Books are updated
CS6806	Digital Image Processing	3(3+0)	• Course code is changed • Title is kept same • Content are changed • Books are updated
CS6807	Network Security	3(3+0)	• Course code is changed • Title is kept same • Content are changed • Books are updated
CS6808	Telecommunication Systems	3(3+0)	• Course code is changed • Title is kept same • Content are changed • Books are updated
CS6809	Introduction to Bioinformatics	3(3+0)	• New course is added • New course code is used
CS6810	Differential Equations	3(3+0)	• New course is added • New course code is used
CS6821	Information Retrieval and Web Search	3(3+0)	• New course is added • New course code is used
CS6822	Service-Oriented Architecture	3(3+0)	• New course is added • New course code is used
CS6823	Wearable Technology	3(3+0)	• New course is added • New course code is used
CS6831	Emerging Computer Networks	3(3+0)	• New course is added • New course code is used
CS6832	Network Administration	3(3+0)	• New course is added • New course code is used
CS6841	Big Data Concepts	3(3+0)	• New course is added

			• New course code is used
CS6842	Database Administration	3(3+0)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6843	ETL (Extract, Transform, Load) Programming	3(3+0)	• Course code is changed • Title is kept same • Contents are changed • Books are updated
CS6851	Software Project Management	3(2+1)	• Course moved into electives from semester VIII • Course code is changed • Title is kept same • Content are changed • Books are updated
CS6852	Software Testing	3(2+1)	• New course is added • New course code is used
CS6853	Open Source Development	3(2+1)	• New course is added • New course code is used
CS6861	Machine Learning	3(3+0)	• New course is added • New course code is used

Courses Archived

The following courses are archived due to not offering any more.

#	Course Code	Course Title	Status
1	CS312	Mathematics - I	Semester - I
2	CS322	Mathematics - II	Semester - II
3	CS323	Physics	Semester - II
4	CS432	Database - I	Semester - III
5	CS435	Electronics	Semester - III

6	CS441	Database - II	Semester - IV
7	CS444	Computer Organization and Assembly Language	Semester - IV
8	CS445	Data Communication and Networking	Semester - IV
9	CS446	Psychology	Semester - IV
10	CS557	Human Resource Management	Semester - IV
11	CS566	Foreign and Regional Language	Semester - VI
12	CS674	Digital Signal Processing	Elective - Semester VII
13	CS677	Data Mining and Data Warehousing	Elective - Semester VII
14	CS678	Management Information System	Elective - Semester VII
15	CS679	Distributed Computing	Elective - Semester VII
16	CS242	Programming Languages II	Elective - Semester VII
17	CS356	Network Strategies	Elective - Semester VII
18	CS687	Database Administration	Elective - Semester VIII
19	CS686	Modeling and Simulation`	Elective - Semester VIII
20	CS689	Multimedia Technologies	Elective - Semester VIII

Semester I

Courses

Course Code	Course Title	Credit Hours
CS3101	Fundamentals of Computers	3(2+1)

Prerequisites: Nil

Course Description: This course is designed for students with little or no computer experience. This course introduces computer concepts, hardware components, basic computer operations and use of software applications to solve problems. Students will have complete understanding and use of personal computers and application software such as Microsoft Word, Excel and PowerPoint.

Aims and Objectives: Students successfully completing this course should be able to:

- Develop a vocabulary of key terms related to the computer and to software programs.
- Identify the components of a personal computer system.
- Demonstrate mouse and keyboard functions.
- Demonstrate window and menu commands and how they are used.
- Demonstrate how to organize files and documents on a USB/hard drive.
- Compose, format and edit a word document.
- Send email messages and navigate and search through the internet.

Course Contents: Data and Information, Information Processing Cycle, Components of a Computer, Advantages and Disadvantages of Using Computers, Categories of Computers, Computer Applications in Society. Keyboard and Pointing Devices, Types of Input, Input for Smart Phones, Game Controllers, Digital Cameras, Voice Input, Video Input, Scanners and Reading Devices, Biometric Input, Terminals. Display Devices, LCD Monitors and LCD Screens, Plasma Monitors, CRT Monitors, Printers, Nonimpact Printers, Impact Printers, Speakers, Headphones, Data Projectors. Interactive Whiteboards, Storage, Hard disks, Flash Memory Storage, Solid State Drives, Memory Cards, USB Flash Drives, Cloud Storage, Optical Discs, Blue-Ray Discs, Magnetic Tapes, Magnetic Stripe Cards and Smart Cards, Microfilm and Microfiche, Enterprise Storage. Motherboard, Processor, Control Unit, Arithmetic Logic Unit, Machine Cycle. Data Representation, Memory Sizes, Types of Memory, RAM, Cache, ROM, Flash Memory. System Software, Operating Systems, Utility Programs. Application Software, Business Software, Graphics and Multimedia Software, Software for Home, Personal, and Educational Use, Web Applications. Application Software for Communications. Internet, World Wide Web, Networks, Intranets. Enterprise Computing, Computer Security Risks, Viruses. Introduction to MS Word, MS Excel, MS PowerPoint.

Recommended Books

1. Shelly, G. B., & Vermaat, M. E. (2012). *Discovering computers fundamentals: your interactive guide to the digital world (Latest ed.)*. Cengage Learning.

Bibliography

1. Sawyer, S. C., & Williams, B. (2000). *Introduction to Using Information Technology (Latest ed.)*. McGraw-Hill Higher Education.
2. Brookshear, G. G., & Brookshear, J. G. (2002). *Computer science: an overview (Latest ed.)*. Addison-Wesley Longman Publishing Co., Inc.
3. O'Leary, T. (2010). *Computing Essentials (Introductory ed.)*. Career Education.
4. Sinha, P.K.(2007). *Computer Fundamentals (6th ed.)*. BPB publication.

Course Code	Course Title	Credit Hours
CS3102	Calculus and Analytic Geometry	3(3+0)

Prerequisites: Nil

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

Aims and Objectives:

- The aim of this course is to give students background of calculus necessary for the proposed computer science studies in the curriculum.

Course Contents: 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.

Recommended Books

1. Thomas, G. B., & Finney, R. L. (1995). *Calculus and Analytic (10th Ed.)*. Addison Wesley.
2. Swokowski, E. W. (1194). *Calculus and Analytical Geometry (6th Ed.)*. rooks/Cole Publishers.

3. Anton, H., Bivens, I., & Davis, S. (2012). *Calculus (10th Ed.)*. Hoboken: Wiley.
4. Anton, H., Bivens, I. C., & Davis, C. (2012). *Calculus (10th Ed.)*. Wiley.
5. Anton, H. (1995). *Calculus with Analytic Geometry: Student Solution Manual (5th Ed.)*. Willy.

Course Code	Course Title	Credit Hours
CS3103	Probability and Statistics	3(3+0)

Prerequisites: Nil

Course Description: Probability has extensive application in many computer science disciplines. This course is intended to fill the gap in students' knowledge of probability.

Aims and Objectives: After completing the course, the student will be able to:

- Understand some advanced probability concepts and use them for problem solving in computer science.

Course Contents: Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. 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, Discrete, Probability Distributions. Continuous Probability Distributions.

Recommended Books

1. Baron, M. (2014). *Probability and Statistics for Computer Scientists* (2nd ed.). CRC Press, Taylor and Francis Group, U.S.
2. Ross, S. (2009). *Probability and statistics for engineers and scientists* (4th Ed.). Elsevier.
3. Hayter, A. (2012). *Probability and statistics for engineers and scientists (Latest ed.)*. Nelson Education.
4. Schiller, J., Srinivasan, R. A., & Spiegel, M. (2008). *Schaum's Outline of Probability and Statistics (3rd Ed.)*. McGraw Hill Professional.

Course Code	Course Title	Credit Hours
CS3104	Functional English	3(3+0)

Prerequisites: Nil

Course Description: This course focuses on teaching of basic language skills: reading, speaking, writing, and listening. The aim is to give students good foundations in basic English with a focus on both accuracy and fluency required for academic progress as well performing specific functions in real life. The course will equip students with the ability to: ask/answer questions, make suggestions, express certainty/uncertainty, give reasons, ask for permission, describe things, agree and disagree, and express likes and dislikes, etc.

Aims and Objectives: After completing the course, the students will be able to:

1. Use grammar and language structure in context.
2. Teaching English through use.
3. Teach different language structures needed in different situations.
4. Make learning English a meaningful and interesting activity

Course Contents: Course contents are divided into the following functions:

Function		**Asking and Answering Questions**
a)	Structure	The Present Perfect
b)	Reading	Guessing the Meanings of Words
c)	Writing	Informal Letters: Beginning and Ending
d)	Listening	Understanding Directions

Function		**Seeking Agreement and Confirmation**
a)	Structure	The Present Perfect and Simple Past Tense

b)	Reading	Guessing the Meanings of Words
c)	Writing	Joining Sentences
d)	Listening	Listening to a Narrative Account

Function		**Agreeing and Disagreeing**
a)	Structure	Reported Speech
b)	Reading	Predicting
c)	Writing	Informal Letters
d)	Listening	Giving Advice

Function		**Possibility/Impossibility**
a)	Structure	Conditionals
b)	Reading	Skimming and Scanning
c)	Writing	Formal Letters
d)	Listening	Listening to Talk/Lecture

Function		**Certainty/Uncertainty: Obligations**
a)	Structure	The Passive
b)	Reading	Function in a Text
c)	Writing	Formal Letters
d)	Listening	Listening to an Interview

Function		**Preferences/Interactions**
a)	Structure	The ing Form
b)	Reading	Reading the Main Idea and Supporting Details in Text
c)	Writing	Formal Letters

d)	Listening	Listening to a Talk/Lecture

Function		**Permission**
a)	Structure	The Past Perfect and Future Perfect Tense
b)	Reading	Classification
c)	Writing	Applying for a Job
d)	Listening	Listening to a Radio Broadcast

Function		**Appreciation, Regret and Indifference**
a)	Structure	Relative Clauses
b)	Reading	Thermatization
c)	Writing	Note Taking
d)	Listening	To an Argument

Function		**Suggesting/Warning**
a)	Structure	Relative Clauses
b)	Reading	Facts and Opinion
c)	Writing	Summarizing
d)	Listening	Listening to a Story.

Recommended Books

1. Bloor, T., & Bloor, M. (2013). *The functional analysis of English (Latest ed.)*. Routledge.
2. Klammer, T. P., Schulz, M. R., & Della Volpe, A. (2000). *Analyzing English Grammar (6th ed.)*. Pearson Education India.
3. CA Exams Study Text. (2015). *Functional English AFC 01 (Latest ed.)*. Emile Wolf International.

Course Code	Course Title	Credit Hours
CS3105	Programming Fundamentals	4(3+1)

Prerequisites: Nil

Course Description: This is the first programming courses in this program. It provides the core knowledge to begin programming. The course covers creating programs to explore data types, conditions, loops, variables, and expressions; working with different kinds of data and seeing how they affect memory**.**

Aims and Objectives: When students complete this course, they will be able to:

- Understand the motivation for programming for a Computer Science (CS) graduate.
- Understand the basic components of a program development environment.
- Analyze a problem and devise a solution for it.
- Implement small programs.
- Define a problem and implement its sub-problems using functions.

Course Contents: 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.

Recommended Books

1. Deitel, P., & Deitel, H. (2016). *C++ How to Program (Latest ed.)*. Prentice Hall.
2. Lafore, R. (2005). *Object-oriented programming in C (Latest ed.)*. Indianapolis, Ind: Sams.

Bibliography

1. Sahay, S. (2012). *Object oriented programming with C (Latest ed.)*. Oxford University Press.
2. Kanetkar, Y. (2004). *Basic programming in C++ (Latest ed.)*. BPB Publications.

Semester II

Courses

Course Code	Course Title	Credit Hours
CS3201	Multivariate Calculus	3(3+0)

Prerequisites: Calculus and Analytical Geometry

Course Description: 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.

Aims and Objectives: On completing this course, students will have:

- An understanding of the basic concepts of multivariable calculus.
- Fluency with such concepts as parametric curves, matrix algebra, gradients, directional derivatives, and multiple integrals will be gained.
- Physical interpretation of these concepts and application in constrained-unconstrained optimization will be acquired.

Course Contents: 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.

Recommended Books

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

Course Code	Course Title	Credit Hours
CS3202	Discrete Structures	3(3+0)

Prerequisites: Calculus and Analytical Geometry, Multivariate Calculus

Course Description: This course is designed to provide students of computer science with several topics and ideas that will help them to develop and analyze algorithms as well as enable them to think about and solve problems in new ways. This course introduces the discrete structures that can be applied to computer science problems.

Aims and Objectives: When students complete this course, they will be able to:

- Express a logic sentence in terms of predicates, quantifiers, and logical connectives.
- Use mathematically correct terminology and notation.
- Apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction, and mathematical induction.
- Count some different types of discrete structures.
- Use tree and graph algorithms to solve problems.

Course Contents: Evaluate Boolean Functions and Simplify Expressions using the Properties of Boolean Algebra, Propositional Logic, Rules of Propositional Logic, Predicate Logic,

Symbols, Tautologies, Quantifiers, Inference Rules, Logic Programming, Recursive Function, Sets Terminology and Operations, Set Identities, Sum Rule, Product Rule, Pigeon-Hole Principle, Permutations, Combinations, Trees in Counting, Inclusion-Exclusion Principle, Discrete Probability, Trees and Graphs, Binary Trees, Recursive Definition of Binary Tree, Applications of Binary Trees, Directed and Un-directed Graphs, Adjacency Matrix, Boolean Algebra Operators and Functions, Functional Completeness, Combinational Circuits, Functions and Relations, Types of Functions and Relations, Regular Expressions, Regular Grammar, Context-Free Grammar.

Recommended Books

1. Rosen, K. H. (2012). *Discrete Mathematics, and its Applications (6th ed.)*. McGraw-Hill.

Bibliography

1. Shaum's. (1992). *Solved Problems Series in Discrete Mathematics (International ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS3203	Pakistan Studies/Islamic Studies	3(3+0)

Prerequisites: Nil

Pakistan Studies:

Course Description: This course introduces students about the historical back ground of the creation of Pakistan. It focuses on major historical events both national and international and their impact.

Aims and Objectives: The course is aimed to:

- Sensitize students about the importance of Pakistan's geographical and strategic position in South Asia.
- Promote the knowledge of Pakistani culture and civilization.
- Aware new generation about the current affairs and important pillars of Pakistan's political system

Course Contents: Ideology of Pakistan in the Historical Perspective, Two Nation Theory, Pakistan Movement, Creation of Pakistan and Role of Quaid-e-Azam, Initial Difficulties, Islamization in Pakistan, The Land of Pakistan

Recommended Books

1. Rabbani, M. I. (2001). *A comprehensive book of Pakistan Studies (3rd ed.)*. The Caravan Press,Lahore, Pakistan.

Islamic Studies:

Course Description: The purpose of the course is to introduce to students the Islamic teachings about basic beliefs, practices, Qura'n and sunnah of the holy prophet (S.A.W.S.) and social, moral and cultural aspects of Islamic way of life.

Aims and Objectives: After completing this course, the students will:

- Have knowledge of and ability to articulate major themes in the study of Islam, gender, and the state, and political system of Islam
- Be able to give an account of pluralism in modern Muslim family law
- Have developed an understanding of central themes in contemporary Muslim family law debates, as well as their historical roots.

Course Contents: Definition and Meaning of Islam, The place of Quran in Islamic World Nations, The Hadith, The Political System of Islam, The Legal System of Islam, Principles of an Islamic State and Chances of Their People.

Recommended Books

1. AbulA'laMaududi, S. (1997). *The Islamic Law and Constitution (12th ed.).* Islamic Publications (Pvt) Ltd, Lahore, Pakistan.

Bibliography

1. Muhammad, F. N. (2000). *Islamiat for Students (2nd ed.)*. Feroz sons (Pvt) Ltd. Lahore, Pakistan.

Course Code	Course Title	Credit Hours
CS3204	Object Oriented Programming	4(3+1)

Prerequisites: Programming Fundamentals

Course Description: 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.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the importance of OOP as compared to Structured Programming.
- Understand the basic constructs of a C++ program.
- Define a problem and implement its solution using classes and objects.
- Effectively use and implement OOP analysis and design.
- Understand object-oriented programming features in C++.
- Understand object-oriented concepts and how they are supported by C++.
- Gain some practical experience of C++.

Course Contents: 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.

Recommended Books

1. Deitel, P., Deitel, H. (2016). *C++ How to Program (Latest ed.)*. Prentice Hall.
2. Laurence, P. (2017). *C++: The Ultimate Crash Course to Learning the Basics of C++ (Latest ed.).*Prentice Hall.

Bibliography

1. Lafore, R. (2005). *Object-oriented programming in C (Latest ed.)*. Indianapolis, Ind: Sams.
2. Kanetkar, Y. (2004). *Basic programming in C++ (Latest ed.)*. BPB Publications.

Course Code	Course Title	Credit Hours
CS3205	Digital Logic Design	3(2+1)

Prerequisites: Nil

Course Description: 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.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the numbering system, boolean algebra, logic gates.
- Understand boolean functions, how to simplify them by using different techniques, and design logic circuit for them.
- Understand the combinational logic circuits, adders, subtractors, decoder/encoder, multiplexer/de-multiplexed.
- Understand the sequential logic circuits, working, purpose and circuitry of flip-flops, registers, counters and memory units.
- Understand the asynchronous sequential logic.
- Use of digital logic simulators, such that the students get hands on familiarity with the concepts they come across in the course.

Course Contents: 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.

Recommended Books

1. Morris, M. M. (2009). *Digital Logic and Computer Design (5th ed.)*. Pearson Education India.
2. Floyd, T. (2011). *Digital Computer Electronics (9th ed.)*. Pearson Education India.

Semester III

Courses

Course Code	Course Title	Credit Hours
MATH-432	Computation in MATLAB	3(2+1)

Prerequisites: Object Oriented Programming

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

Aims and Objectives: When students complete this course, they will be able to:

- Write small programs for mathematical problems and to perform computations in MATLAB.
- Use MATLAB effectively.

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

Recommended Books

1. Lipsman, R. L., & Rosenberg, J. M. (2001). *A Guide to MATLAB (Latest ed.)*. Cambridge University Press Textbooks.
2. Etter, D. M., Kuncicky, D. C., & Hull, D. W. (2002). *Introduction to MATLAB 6 (Latest ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS4301	Data Structures and Algorithms	4(3+1)

Prerequisites: Programming Fundamentals

Course Description: 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. This course is also about showing the correctness of algorithms and studying their computational complexities. This course offers the students a mixture of theoretical knowledge and practical experience.

Aims and Objectives: Students successfully completing this course should be able to:

- Be familiar with basic techniques of algorithm analysis.
- Be familiar with writing recursive methods.
- Master the implementation of linked data structures such as linked lists and binary trees.
- Be familiar with several sub-quadratic sorting algorithms including quicksort, mergesort and heapsort.

Course Contents: 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).

Recommended Books

1. Miller, B. N., & Ranum, D. L. (2011). *Problem Solving with Algorithms and Data Structures Using Python (2nd Ed.)*. Franklin, Beedle & Associates Inc.
2. Lambert, K. (2014). *Fundamentals of Python: Data Structures (Latest ed.)*. Nelson Education.

Course Code	Course Title	Credit Hours
CS4302	Communication Skills	3(3+0)

Prerequisites: Functional English

Course Description: This course aims to develop students' ability to focus on the outcome, tune in to their audience and develop their message for clarity and impact. It enhances their ability to create an environment for open discussion and ongoing dialogue which is crucial for communication success.

Aims and Objectives: The course aims to:

- Enable the students to meet their real-life communication needs.
- Provide well defined goals for more effective communications
- Provide the ability to create an open environment for communication
- Provide the skill to communicate clearly
- Provide emotional intelligence to deal with difficult situations

Course Contents: Paragraph writing: Practice in writing a good, unified and coherent paragraph. Essay writing, CV and job application, Translation skills, Study skills: Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension, Academic skills: Letter/memo writing, minutes of meetings, use of library and internet, Presentation skills: Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books

1. Thomson, A. J., Martinet, A. V., & Draycott, E. (1986). *A practical English grammar (3rd Ed.)*. Oxford University Press.
2. Boutin, M., Brinand, S., and Grellet, F. (1993). *Intermediate by. Oxford Supplementary Skills (Third Impression)*. Oxford Press.
3. Nolasco, R. (1992). *Upper-Intermediate by. Oxford Supplementary Skills (Third Impression)*. Oxford Press.
4. Tomlinson, B., and Ellis, R. (1991). Advanced by Oxford Supplementary Skills (Third Impression). Oxford Press. 1991. ISBN 0 19 453403 0.
5. Langan, J. (1978). *Reading and Study Skills (Latest ed.)*. Mc Graw-Hill.

Course Code	Course Title	Credit Hours
CS4303	Data Communication	3(3+0)

Prerequisites: Nil

Course Description: Data communication is the fundamental course about the concept, design and management of data over a network. This course focuses on the components of communication system, the representation of data and the transmission mechanisms. The main focus of the course is on the physical layer of the OSI model.

Aims and Objectives: When students complete this course, they will be able to:

- Identify the different components and their respective roles in a communication system.
- How the data is represented in analog and digital forms.

- Identify the transmission mechanism and the induced challenges.

Course Contents: Data Transmission Concept, Introduction to Data Communication, Advantages of Digital Communication, Communication Model, Codes for Digital Signal Transmission, Parallel and Serial Transmission, Synchronous and Asynchronous Transmission, Baseband and Broadband Transmission, Simplex, Half-duplex and Full-duplex Transmission, Modems, Types of Modems, Properties of Modems. Transmission Impairments, Attenuation, Delay Distortion, Noise, Channel Capacity, Transmission Media, Guided Transmission Media, Twisted Pair, Coaxial Cable and Optical Fiber, Wireless Transmission- Terrestrial & Satellite Microwave and Broadcast Radio, Data Encoding, Digital and Analog transmission, ASK, PSK, QAM, Digital Data & Digital Signals, Line Coding Schemes, Block Coding, Scrambling, Analog Data & Digital Signals, Pulse Code Modulation (PCM), Delta Modulation (DM), Analog Data & Analog Signals, AM, FM, PM, Data Communication Interface, Line Configuration, Interfacing, Null Modem, Point to Point and Multipoint Link, Physical Layer and Media, Analog and Digital Data, Periodic and Aperiodic signal, Sine Wave, Phase, Wavelength, Time and Frequency Domain, Composite Signal and Bandwidth, Digital Signals, Bit Rate, Bit Length, Transmission of Digital Signals, Data Rate Limits, Noiseless Channel, Nyquist Bit Rate, Noisy Channel, Shannon Capacity, Performance, Throughput, Latency, Jitter, Multiplexing, Frequency Division Multiplexing, Synchronous and Statistical Time Division Multiplexing, Spread spectrum. Error Correction and Detection, CRC, FEC etc.

Recommended Books

1. Stallings, W. (2007). *Data and Computer Communications (8th Ed.)*. Prentice Hall.

Bibliography

1. Forouzan, B. A. (2012). *Data Communications and Networking (Global Ed.)*. McGraw Hill.
2. Tenanbaum, A. S. (2003). *Computer Networks (4th Ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS4304	Linear Algebra	3(3+0)

Prerequisites: Nil

Course Description: This elementary course in linear algebra prepares students for learning advanced concepts in computer science.

Aims and Objectives: After studying this course, students will be able:

- To understand the use of linear algebra in some computer science concepts and apply it to computer science problems.

Course Contents: 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. The Transform.

Recommended Books

1. Strang, G. (2009). *Introduction to Linear Algebra (4th Ed.)*. Wellesley Cambridge Press.

Bibliography

1. Poole, D. & Cole, B. (2010). *Linear algebra: A modern introduction (3rd Ed.)*. Cengage Learning.
2. Kolman, B. & Hill, D. (2007). *Elementary Linear Algebra with Applications (9th Ed.)*. Prentice Hall.
3. Strang, G. & Coonley, B. (2005). *Strang's Linear Algebra And Its Applications (4th Ed.)*. Brooks/Cole.
4. Anton, H. (2005). *Elementary Linear Algebra: Applications Version (9th Ed.)*. Wiley.

Course Code	Course Title	Credit Hours
CS4305	Artificial Intelligence	3(3+0)

Prerequisites: Programming Fundamentals, Discrete Structures

Course Description: Artificial intelligence (AI) is an area of computer science that emphasizes the creation of intelligent machines that work and reacts like humans. This course introduces Artificial Intelligence. It covers the basics of modern AI as well as some of the representative applications of AI.

Course Contents: Basic Concepts: Intelligence, Artificial Intelligence, Branches of Artificial Intelligence. Tools: Prolog language, LISP language, Expert System Shells. Techniques: Searching (Blind search, knowledge-directed search); Knowledge Representation (Logic, Rules, Semantic Networks, scripts).Applications: Natural Language Processing, Expert Systems

Recommended Books

1. Partridge, D. (1986). *Artificial intelligence: applications in the future of software engineering (Latest ed.)*. Halsted Press.
2. Rich, E., & Knight, K. (1991). *Artificial intelligence (Latest ed.)*. McGraw-Hill, New. York.
3. Tanimoto, S. T. (1987). *The Elements of Artificial Intelligence: An Introduction Using LISP (Latest ed.)*. Computer Science Press, W.H.Freeman and Company.
4. Orban, G. A., & Nagel, H. H. (2012). *Artificial and biological vision systems (Latest Editoin)*. Springer Publishing Company, Incorporated.
5. Luger, G. F. (2005). *Artificial intelligence: structures and strategies for complex problem solving (Latest ed.)*. Pearson education.

Bibliography

1. Jones, M. T. (2015). Artificial Intelligence: *A Systems Approach: A Systems Approach (Latest ed.)*. Jones & Bartlett Learning.

Semester IV

Courses

Course Code	Course Title	Credit Hours
CS4401	Database Systems	4(3+1)

Prerequisites: Data Structures and Algorithms

Course Description: Establish proficiency in the fundamental concepts of database systems and the database system development life cycle of an enterprise database.. It discusses the theoretical foundations of database architecture, Relational Algebra and Relational calculus. This course also focuses on the principles, design and implementation of multi-user databases and its applications in client/server environment.

Aims and Objectives: When students successfully complete this course, they will be able to:

- Understand intricacies involved in the design and implementation of a database system.
- Have in-depth knowledge of entity-relationship (ER) modeling
- Demonstrate competence with the fundamental tasks involved in gathering and analyzing user requirements, build conceptual, logical, and physical data models that reflect the organization's requirements.
- Apply normalization techniques.
- Query a relational DBMS to create and maintain databases in a client server environment.

Course Contents: Introduction to database systems, The Relational Data Model, Relational Algebra and Relational Calculus, Database environment, Database Management System, Conceptual database modeling using the entity-relationship model and Enhanced Entity-Relationship modeling, Schema quality through the study of functional dependencies and normalization, Logical and Physical Database Design, The SQL (DDL, DML, and DCL), Database application development, data integrity, constraints (entity integrity, referential integrity, domain integrity etc.), Database Transaction Management.

Recommended Books

Connolly, T. M., & Begg, C. E. (2014). *Database Systems: A Practical Approach To Design, Implementation And Management (6th Ed.)*. Addison Wesley Publishing Company.

Bibliography

Ramakrishnan, R., & Gehrke, J. (2003). *Database Management Systems (3rd Ed.)*. WCB/McGraw Hill.

Elmasri, R., & Navathe, S.B. (2016). *Fundamentals of Database Systems (Global Ed.)*. Pearson Education Limited.

Hoffer, J., Venkataraman, R., & Topi, H. (2015). *Modern database management (Latest ed.)*. Prentice Hall Press.

Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). *Database system concepts (4th Ed.)*. New York: McGraw-Hill.

Course Code	Course Title	Credit Hours
CS4402	Operating Systems	4(3+1)

Prerequisites: Programming Fundamentals, Data Structure and Algorithms

Course Description: 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.

Aims and Objectives: When students complete this course, they will be able to:

- To understand the services provided by and the design of an operating system.
- To understand what a process is and how processes are synchronized and scheduled.
- To understand different approaches to memory management.

Course Contents: 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.

Recommended Books

1. Silberschatz, A., Galvin, P. B., Gagne, G., & Silberschatz, A. (2012). *Operating system concepts (9th Ed.)*. John Wiley & Sons.

Bibliography

1. Ritchie,C. (2003). *Operating Systems (4th Ed.)*. BPB Publications.

Course Code	Course Title	Credit Hours
CS4403	Computer Networks	3(3+0)

Prerequisites: Data Communication

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

Aims and Objectives: When students complete this course, they will be able to:

- Understand the fundamental concepts of networking.
- Know different protocols and working.
- Identify the challenges involved in data flow and error control.

Course Contents: 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.

Recommended Books

1. Stallings, W. (2007). *Data and Computer Communications (8th Ed.)*. Prentice Hall.
2. Forouzan, B. A. (2007). *Data Communications and Networking (4th Ed.)*. McGraw Hill.
3. Tenanbaum, A. S. (2003). *Computer Networks (4th Ed.)*. Prentice Hall.
4. Forouzan, B. A., & Mosharraf, F. (2012). *Computer Networks: A Top-down Approach (Latest ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS4404	Theory of Automata	3(3+0)

Prerequisites: Programming Fundamentals, Discrete Structures, Data Structures and Algorithms

Course Description: 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.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the working of computer at abstract level.
- Design software and some electronic circuits.
- Understand the basic theory behind computer languages.

- Have a sound background for Translator software.

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

Recommended Books

1. Cohan, D. A. (1997). *Introduction to Computer Theory (2nd Ed.)*.
2. Kellye, D. (1998). *Automata and Formal Languages: An Introduction (1st Ed.)*. Prentice Hall.
3. Spiser, M. (2007). *Theory of Computation (Latest ed.)*. Cengage Learning.

Course Code	Course Title	Credit Hours
CS4405	Web Technologies	4(3+1)

Prerequisites: Fundamentals of Computers, Object Oriented Programming

Course Description: This course provides a detailed presentation and understanding of the basic concepts and principles of the World Wide Web and the essential web development languages, tools, and technologies. Course content will focus on introducing and familiarizing students with the basic tools required for web programming including HTML,

CSS, JavaScript, and server-side programming using PHP. Questions such as what are they, when should we use these languages, for what purpose and to what extent these languages help us create modern, engaging and stable websites will be covered. 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 for basic interactivity and client-side scripting, and create dynamic web pages by implementing server-side script to perform operations on a web server. A key part of this course is its problem-based approach which requires students to design and create a website of ever-increasing sophistication as the course progresses.

Aims and Objectives: When students complete this course, they will be able to:

- Know the fundamentals of web application architecture and web programming.
- Apply a structured approach to identifying needs, interests, and functionality of a website.
- Design dynamic websites that meet specified needs and interests.
- Write well-structured, easily maintained, standards-compliant, accessible HTML code.
- Write well-structured, easily maintained, standards-compliant CSS code to present HTML pages in different ways.
- Use JavaScript for client-side scripting and add dynamic content to pages.
- Use PHP to implement server-side script for creating dynamic web pages and access databases.
- Design and implement an interactive web site(s) with regard to issues of usability, accessibility, and internationalisation.
- Further study web technologies, both those that exist today and those that will be developed in the future.
- Work in collaborative environment by working in group assignments.

Course Contents: 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), Installing and Configuring Apache and PHP, 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, and Database, AJAX, Introduction to Service Oriented Architecture and Web Services, Designing and Implementing Web Services with SOAP and JSON.

Recommended Books

1. Duckett, J. (2014). *Web Design with HTML, CSS, JavaScript and jQuery Set (Latest ed.)*. Wiley Publishing.
2. Nixon, R. (2015). *PHP: 20 Lessons to Successful Web Development (Latest ed.)*. McGraw-Hill Education Group.
3. Nixon, R. (2012). *Learning PHP, MySQL, JavaScript, and CSS: A step-by-step guide to creating dynamic websites (Latest ed.)*. O'Reilly Media, Inc.

Bibliography

1. Boronczyk, T., Naramore, E., Gerner, J., Scouarnec, Y. L., & Stolz, J. (2009). *Beginning PHP 6, Apache, MySQL 6 Web Development (Latest ed.)*. Wrox Press Ltd.

Semester V

Courses

Course Code	Course Title	Credit Hours
CS5501	Design and Analysis of Algorithms	3(3+0)

Prerequisites: Programming Fundamentals, Data Structures and Algorithms

Course Description: This core course covers good principles of algorithm design, elementary analysis of algorithms, and fundamental data structures. The emphasis is on choosing appropriate data structures and designing correct and efficient algorithms to operate on these data structures.

Aims and Objectives: When students successfully complete this course, they will be able to:

- Understand how to design computer software.
- What can be the most efficient solution (algorithm) for the in hand problems.
- How a very time consuming task can be made very efficiently.
- How to utilize multiple cores of computer using parallelism.

Course Contents: Algorithm introduction, properties of correct algorithms, factors influencing the performance of algorithms (not in control of the programmer), of algorithms (in control of the programmer), Analysis of Algorithms: computational complexity, order of growth and runtime of an algorithm, T(n), some examples to calculate the T(n) of algorithms (including examples from searching and sorting), Asymptotic Notations, usefulness and limitations of the Asymptotic notation, Implementation of algorithms, rules for implementation, empirical analysis, Introduction to Generating functions, Divide and conquer approach: full exploration using examples, complete understanding of recursion, Basic Recurrences, Recurrence Solutions (e.g. using master theorem, iterative method, substitution method), Examples to calculate the T(n) of recursive algorithms, Dynamic programming, Greedy algorithms, Evolutionary Algorithms, Genetic Algorithms, Swarm Optimization Algorithms, Ant Colony Optimization Algorithms, Parallel Algorithms and Parallel Programming, Introduction to supercomputing.

Recommended Books

1. Cormen, T. H. (2009). *Introduction to algorithms (Latest ed.)*. MIT press.
2. Sedgewick, R., & Flajolet, P. (2013). *An introduction to the analysis of algorithms (Latest ed.)*. Addison-Wesley.

Bibliography

1. Roosta, S. H. (2012). *Parallel processing and parallel algorithms: theory and computation (Latest ed.)*. Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS5502	Object Oriented Analysis and Design	3(2+1)

Prerequisites: Object Oriented Programming

Course Description: The course introduces the concepts and methods required for the development of large software intensive systems. The aim is to develop a broad understanding of the discipline of software engineering. The course focuses on the object-oriented approach for analysis and design. Students will understand the difference between writing programs and doing analysis and design. Problem analysis and solution design will be emphasized. Students will work in teams and will be responsible for analysis, design and implementation of a software system. Automated Software engineering tools will be introduced in several stages of the development process. It provides a brief account of associated professional and management issues.

Aims and Objectives: The course is designed to:

- Develop a working understanding of formal object-oriented analysis and design processes.
- Develop an understanding of the application of object oriented analysis and design practices from a software project management perspective.
- Provide details of software development and make students visualize software development process.
- Enable students to identify, formulate, and solve software development problems.

- Make students build object oriented analysis and design artifacts
- Introduce the techniques, skills, and modern engineering tools necessary for software engineering practice.

Course Contents: Software development life cycle (SDLC), Understanding large scale project perspective, Object Oriented Analysis and Development concepts. Analysis vs Object Oriented Analysis (OOA), Object Modeling, Object Modeling Technique (OMT), Unified Modeling Language (UML) for modeling, using UML modeling tools, OOA: Requirement gathering and development, Requirements categories FURPS+, Modeling and analyzing requirements, Analysis modeling (Scenarios, Use Case, User Stories). Requirement prioritization, verifying and validating requirements, Requirement specification, Object Oriented Design (OOD): Principles of OOD, SOLID (Single-responsibility Principle, Open-Closed Principle, Liskov Substitution Principle, Interface Segregation Principle, Dependency Inversion Principle), Identifying objects and entities, Designing Data Model (ERD), Relationships and associations. Mapping concepts, O/R Mapping, Shadow information and scaffolding, Mapping metadata, Mapping inheritance, Mapping object relationships, Mapping relational database relationships. UML modeling (structured and behavior diagrams. Concept of static, dynamic and functional model), Structural diagrams and use, Behavioral diagrams and use, User Interface (UI) design process, State machines, Architectural analysis, Architectural styles, Software implementation, Use of right tools for implementation, Selecting algorithms, Software testing:Test Case design, Levels of testing: Unit testing, Integration testing, Acceptance testing, Regression testing, Testing object-oriented systems, Use-case based testing, Class diagram based testing, Sequence diagram-based testing, Writing and using basic unit tests, Concept of deployment and cutover, Basic deployment tasks.

Recommended Books

1. Stephens, R. (2015). *Beginning software engineering (Latest ed.)*. Indianapolis: Wrox Publishing.
2. Ambler, S. W., & Lines, M. (2012). *Disciplined Agile Delivery: A Practitioner's Guide to Agile Software Delivery in the Enterprise (1st Ed.)*. IBM Press.
3. Eriksson, H. (2004). *UML 2 toolkit (Latest ed.)*. Indianapolis, IN: Wiley Publishing.

Bibliography

1. Larman, C. (2005). Applying UML and patterns: an introduction to object-oriented analysis and design and iterative development (3rd Ed.). Upper Saddle River, NJ: Prentice Hall Professional Technical Reference.
2. McConnell, S. (2004). *Code complete: Code complete: a practical handbook of software construction (2nd Ed.)*. Redmond (Washington): Microsoft Press.

Course Code	Course Title	Credit Hours
CS5503	Advanced Programming	4(3+1)

Prerequisites: Object Oriented Programming, Operating Systems

Course Description: 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.

Aims and Objectives: This course assumes that students know the basic concepts of Object Oriented Programming. When students complete this course, they will be able to:

- Create Java application using sound OOP practices.
- Create multi-threaded applications which can execute faster on current multi-core architectures.
- Create network and distributed applications.
- Create event driven Graphical User Interfaces (GUIs).
- Create Java applications connected to databases.
- Understand how Java can be used for Functional programming.

Course Contents: 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.

Recommended Books

1. Deitel, H., Deitel, P. (2015). *Java How to Program (Latest ed.)*. Prentice Hall.
2. Schildt, H. (2017). *Java: A Beginners Guide (Latest ed.)*. McGraw-Hill Education.

Bibliography

1. Schildt, H. (2017). *Java: The Complete Reference (Latest ed.)*. McGraw-Hill Education.

Course Code	Course Title	Credit Hours
CS5504	Information Security	3(3+0)

Prerequisites: Object Oriented Programming, Database Systems, Computer Networks, Web Technologies

Course Description: The protection of information assets underpins the commercial viability and profitability of all enterprises and the effectiveness of public sector organizations. It should not be left to chance. If you work in an organization concerned (directly or indirectly) with valuable information assets, this practical course will enable you to understand and manage strategic and operational aspects of information security, including IT governance and risk analysis and management. It will also provide the knowledge and skills needed to plan the implementation of an information security management system that provides efficient, effective safeguards and responds to your organization's needs.

Course Objectives: When students complete this course, they will be able to:

1. Understand contemporary issues in information security management
2. Analyze and prioritize information security risks
3. Identify countermeasures and review techniques appropriate to the management of information security risks
4. Understand the policy and technology trade-offs involved in developing information security systems of adequate quality
5. Locate, read, comprehend and evaluate developments in the field as they appear in contemporary professional and research publications.

Course Contents: Security Management: Need, Aims and Objectives of Security Management, Various Approaches to Solve Security Problems, Cryptography and Security Mechanisms: Main Types of Cryptographic Mechanism, Security Services, Key Management, Cryptographic Algorithms, Network Security: Networking Security Technologies, User Identification Techniques, Authentication Protocols and Key Distribution Mechanisms, Security Solutions for a Variety of Types of Practical Networks, include LANs, WANs, Proprietary Computer Networks, Mobile Networks and Electronic Mail, Computer Security: Security Requirements/Policy, Security Models, Security Features and Mechanisms in Operating Systems, Security-related Issues of Computer Architecture, Security of Middleware, Software Protection and Web Security, Secure Electronic Commerce and other Applications, Standards and Evaluation Criteria, Database Security: Concurrency Control in Distributed Databases, Methods for Concurrency Control and Failure Recovery in Distributed Databases and the Interaction Between those Methods and Security Requirements, Adapting Access Control Policies to Relational and Object-Oriented Databases, Information Crime: History, Causes, Development and Repression through Studies of Surveys, Types of Crime, Legal Measures, and System and Human Vulnerabilities, Effects of Computer Crime, Motives and Attitudes of Hackers and other Computer Criminals.

Recommended Books

1. Stamp, M. (2011). *Information security: principles and practice (Latest ed.)*. John Wiley & Sons.

2. Stamp, M. (2003). *Information Security (Latest ed.)*. Principles and Practice, Wiley-Interscience Publishers.
3. Anderson, R.J. (2008). *Security Engineering: A Guide to Building Dependable Distributed Systems (Latest ed.)*. Wily Publishers.
4. Layton, T. P. (2006). *Information Security: Design, Implementation, Measurement, and Compliance (Latest ed.)*. Auerbach Publications.
5. Tipton, T. P. & Krause, M. (2008). *Information Security Management Handbook (Latest ed.)*. Auerbach Publications.

Course Code	Course Title	Credit Hours
BES-475	Geographic Information System	3(3+0)

Prerequisites: Nil

Course Description: The course introduces the principles of Geographic Information System as tool for data collection and analysis.

Aims and Objectives: When students complete this course, they will be able to:

- Understand fundamental concepts and practices of Geographic Information Systems (GIS).
- Apply basic graphic and data visualization concepts.
- Demonstrate proficiency in the use of GIS tools to create maps that are fit-for-purpose and effectively convey the information they are intended to.
- Give examples of interdisciplinary applications of Geospatial Information Science and Technology.

Course Contents: Fundamentals of GIS, Components of GIS, Hardware and Software, Maps, Spatial Data (Point Line, Area) Structure (Vector, Raster), Attribute Data, Data Input, Digitizing, Scanning, Manual Coordinate Entry, Data Linkage, Use of Remotely Sensed Data and Global Positioning System in GIS, Database Systems, Types: Hierarchical, Relational, Network Types, Data Analysis and Output, Data Storage, Classification, Reclassification, Measurement Operations, Arithmetic, Geometric and Statistical Operation, Overlay and Buffering, Digital Elevation Models (DEM), Construction, Importance Calculating Slope Angle and Direction, Important Aspects in the Design of Out Maps, Data Output Types, Cartographic Tools and Visual Variable, GIS Application

Recommended Books

1. Lulla, K. P., & Dessinov, L. V. (2000). *Dynamic Earth Environments: remote sensing observations from shuttle-Mir missions (Latest ed.)*. John Wiley & Sons.
2. Rancez, A.N. (1999). *Remote Sensing for the Earth Sciences (Latest ed.)*. John Wiley & Sons. Inc.
3. Foody, G.M., & Curran, P.J. (1994). *Environmental Remote Sensing from Regional to Global scales (Latest ed.)*. John Wiley & Sons. Inc.
4. Murai, S. (Ed). (1996). Remote *Sensing Note, 2nd ed. Japan Association on Remote Sensing (Latest ed.)*.
5. Lillesand, T.M. & Kiefer, R.W, *Remote Sensing and image Interpretation (Latest ed.)*. John Wiley & Sons In..
6. Paine, D. P., & Kiser, J. D. (2003). *Aerial photography and image interpretation (Latest ed.)*. John Wiley & Sons.
7. Luder D.R. *Aerial Photographic Interpretation (Latest ed.)*.
8. Waless H.R. *Introduction to Aerial Stereo-photographs (Latest ed.)*.
9. Burrought, P.A. (1993*). Principles of Geographic Information System for land resources assessment (Latest ed.)*. Clarendon Press Oxford.
10. Bernhardsen, T. (1992). *Geographic information Systems, The Microcomputer and modern cartography (Latest ed.)*. Pergamon press.

Semester VI

Courses

Course Code	Course Title	Credit Hours
CS5601	Computer Organization and Architecture	4(4+0)

Prerequisites: Digital Logic Design

Course Description: Modern computer technology requires an understanding of both hardware and software, as the interaction between the two offers a framework for mastering the fundamentals of computing. This course covers basics of modern computer organization and architectures. The emphasis is on understanding the interaction between computer hardware and software at various levels. The students will learn the concepts of computer technology, performance evaluation, instruction set design, computer arithmetic, data path and control unit design of processors and enhancing performance with pipelining.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the underlying organization of modern computing systems.
- Understand microprocessor organization and architecture.
- Understand performance analysis and evaluation.
- Understand arithmetic logic unit and control unit implementations.
- Understand pipelined processor organization and hazards.

- Understand memory hierarchy and storage devices.
- Understand multiprocessors.

Course Contents: 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.

Recommended Books

1. Patterson, D. A., & Hennessy, J. L. (2013). *Computer Organization and Design the Hardware/Software Interface (Latest ed.)*. Morgan Kaufmann.

Bibliography

1. Hennessy, J. L., & Patterson, D. A., (2012). *Computer Architecture: A Quantitative Approach (Latest ed.)*. Morgan Kaufmann.

Course Code	Course Title	Credit Hours
CS5602	Software Engineering	3(3+0)

Prerequisites: Object Oriented Analysis and Design

Course Description: This course builds upon the concepts presented in Object Oriented Analysis and Design course. The students will be provided with 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 an 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.

Aims and Objectives: After completing his course, the students will be able to:

- Use and apply different state of the art software development methodologies.
- Understand success and failure indicators, advantages, and disadvantages of different methodologies.
- Understand and apply agile software development through Extreme Programming methodology which focuses on human factor along with technical details of software development.
- Have a hands-on experience with a complete software development project simulating the industry like environment through practices of extreme programming methodology.

Course Contents: Introduction and comparison of important software process models, Predictive Models (Waterfall Model, Waterfall with Feedback, V-Model. Success and failure indicators, advantages and disadvantages), Incremental Models (Prototyping Model, Spiral Model, Rational Unified Process, advantages and disadvantages), Agile Models, Lean vs Agile Principles, Extreme Programming (XP) Process, XP Roles, Principles, Values and Practices, Planning Game, Releases and Iterations, Test Driven Development, Refactoring, Pair Programming, Collective Ownership, Continuous Integration, On-site Customer, Coding Standards, Agile Project Management Concepts, Open Source Development (OSS vs FOSS), Commercial off-the-shelf development Process Model.

Recommended Books

1. Stellman, A. (2013). Learning Agile: Understanding Scrum, XP, Lean, and Kanban (1st Ed.). O'Reilly Media.

2. Stephens, R. (2015). Beginning software engineering (1st Ed.). Indianapolis: Wrox Publishing.

Bibliography

1. Beck, K., & Andres, C. (2012). Extreme programming explained: embrace change (2nd Ed.). Boston: Addison-Wesley.
2. Martin, R. C., Feathers, M. C., Ottinger, T. R., Langr, J. J., Schuchert, B. L., Grenning, J. W., & Wampler, K. D. (2015). Clean code: a handbook of agile software craftsmanship (Latest ed.). Upper Saddle River, N.J: Prentice Hall.
3. Larman, C. (2005). Applying UML and patterns: an introduction to object-oriented analysis and design and iterative development (3rd Ed.). Upper Saddle River, NJ: Prentice Hall Professional Technical Reference.

Course Code	Course Title	Credit Hours
CS5603	Mobile Applications Development	4(3+1)

Prerequisites: Programming Fundamentals, Object Oriented Programming

Course Description: 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.

Aims and Objectives: When students complete this course, they will be able to:

- Describe those aspects of mobile programming that make it unique from programming for other platforms.
- Critique mobile applications on their design pros and cons.
- Utilize rapid prototyping techniques to design and develop sophisticated mobile interfaces.
- Program mobile applications for the Android operating system that use basic and advanced phone features.
- Design, implement, test, debug and publish smartphone applications.
- Deploy applications to the Android marketplace for distribution.
- Create innovative and robust example mobile applications that will be valuable addition to their programming portfolio.
- Work in collaborative environments by working in group projects.

Course Contents: 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, Linear Layout, Relative Layout, Table Layout, Scrollview Layout, List View, Actionbar, Dialogs and Notification, Mlti-threading, Location and Maps Services, Shared Preferences, Creating and Using Database, Content Providers, Accessing External Storage, Displaying Videos and Listing Audios Using Media Player, Accessing and Handling Sensors, Publishing and Deploying Applications on Android Market.

Recommended Books

Bibliography

1. Horton, J. (2015). *Android Programming for Beginners (Latest ed.)*. Packt Publishing Ltd.
2. Phillips, B., & Hardy, B. (2013). *Android programming: the beginners guide (Latest ed.)*. Pearson Education.
3. Lee, W. M. (2012). *Beginning android 4 application Development (Latest ed.)*. John Wiley & Sons.

1. Meier, R. (2012). *Professional Android 4 application development (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS5604	Human Computer Interaction	3(3+0)

Prerequisites: Fundamentals of Computers, Programming Fundamentals

Description: This course aims to give students some basic understanding of the area of Human Computer Interaction and introduces students to various methods and techniques that could be used to design and evaluate interactive systems.

Aims and Objectives: Students successfully completing this course should be able to:

- Demonstrate knowledge and understanding of the main concepts (conceptual model, metaphors, and paradigms) that influence human-computer interaction
- Understand to design, prototype and evaluate a user interface for an interactive system.
- Choose appropriate methods of evaluating an interactive system.

Course Contents: Human and Computer and Interactions, Human Psychology and Ergonomics, Interaction Paradigms, Usability Paradigm and Principles, Interaction Design Basics, Prototyping HCI in the Software Process, Design Rules, Implementation Support, Evaluation Techniques, Heuristic Evaluation, Cognitive Walkthrough, Participatory Design, Observational Methods, Universal Design, User Support, ,Cognitive Models, Socio - Organizational Issues and Stakeholder Requirements, Communication and Collaboration Models, Task Analysis, Models of the System, Modeling Rich Interaction, Groupware, Augmented Realities Pervasive and Ubiquitous Applications.

Recommended Books

1. Dix, A., & Beale, R. (2003). *Human-Computer Interaction (Latest ed.).* Prentice Hall.
2. Rogers, Y., Sharp, H., & Preece, J. (2014). *Interaction Design (4th Ed.)*. Wiley & Sons.

Course Code	Course Title	Credit Hours
CS5605	Applied Image Processing	3(2+1)

Prerequisites: Nil

Course Description: The course provides an opportunity to students to gain an insight into applied image processing. Students will implement image processing algorithms in MATLAB or other tools and complete a graduate level project.

Aims and Objectives: When students complete this course, they will be able to:

- Implement image processing algorithms in MATLAB or other appropriate tools.
- Gain familiarity with the practical aspects of the concepts and techniques in digital image processing.

Course Contents: Intensity Transformations, Linear and Nonlinear Spatial Filtering, Filtering in the Frequency Domain, Image Restoration and Registration, Color Image Processing, Wavelets, Image Data Compression, Morphological Image Processing, Image Segmentation, Regions and Boundary Representation and Description, and Object Recognition.

Recommended Books

1. Yaroslavsky, L. P. (2016). *Advanced Digital Imaging Laboratory Using MATLAB (Latest ed.)*. IOP Publishing Ltd.
2. Yaroslavsky, L. P. (2012). *Theoretical Foundations of Digital Imaging Using MATLAB (Latest ed.)*. CRC Press.
3. Gonzalez, R. C., Woods, R. E., Eddins, S. L. (2009). *Digital Image Processing Using MATLAB (Latest ed.)*. Gatesmar Publishing.

Semester VII

Courses

Course Code	Course Title	Credit Hours
CS6701	Technical Writing	3(3+0)

Prerequisites: Nil

Course Description: This course introduces students to different aspects of technical writing in the context of academic writing for computer science.

Aims and Objectives: When students complete this course, they will be able to:

- Understand requirements of technical and academic writings in computer science.
- Have familiarity of different aspects of technical writing.
- Have improved technical writing skills.
- Have understanding of how to avoid informal language in academic writing.

Course Contents: 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.

Recommended Books

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

Course Code	Course Title	Credit Hours
BA565	Entrepreneurship	3(3+0)

Prerequisites: Nil

Course Description: 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.

Aims and Objectives: When students complete this course, they will be able to:

- Identify and assess sources of support for small businesses and entrepreneurs.
- Identify the critical factors that are used to identify business start-up ideas – including forms of ownership.
- Identify the financial, marketing, legal, human resource, operations, and general management skills that are necessary to successfully launch and operate a successful new venture.
- Identify the critical concepts of business planning.
- Increase the chances for business success.
- Seek out financing sources for start-ups.
- Discuss examples of current entrepreneurs.

Course Contents: 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.

Recommended Books

1. Hisrich,R., Peters, M., & Shepherd, D. (2012). *Entrepreneurship (9th Ed.)*. McGraw-Hill/Irwin.
2. Greene, C. L. (2011). *Entrepreneurship: Ideas in Action (5th Ed.)*. South-Western Educational Pub.

Bibliography

1. Bygrave, W. D. & Zacharakis, A. (2010). *Entrepreneurship (2nd Ed.)*. Prentice Hall.
2. Kuratko, D. F. (2008). *Entrepreneurship: Theory, Process, and Practice (8th Ed.)*. South-Western College Pub.
3. Barringer, B. R., & Ireland, D. (2011). *Entrepreneurship: Successfully Launching New Ventures (4th Ed.)*. Prentice Hall.

Seventh (7th) Semester Specializations Elective Courses

Course Code	Course Title	Credit Hours
CS6703	Compiler Construction	3(3+0)

Specialization: General Track

Prerequisites: Programming Fundamentals, Theory of Automata

Course Description: The course is intended to teach the students the basic techniques that underlie the practice of Compiler Construction. The course will introduce the theory and tools that can be employed in order to perform syntax-directed translation of a high-level programming language into an executable code. These techniques can also be employed in wider areas of application, whenever we need a syntax-directed analysis of symbolic expressions and languages and their translation into a lower-level description. They have multiple applications for man-machine interaction, including verification and program analysis. 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 deeper insights into the more advanced semantics aspects of programming languages, such as recursion, dynamic memory allocation, types and their inferences, object orientation, concurrency and multi-threading.

Aims & Course Objectives: Students successfully completing this course should be able to:

- Understand programming language concepts deeply.
- Understand processing of programming languages by computers.
- Have full command on techniques used by Translator software.

Course Contents: 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.

Recommended Books

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

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

Course Code	Course Title	Credit Hours
CS6704	E-Commerce Technologies & Applications	3(3+0)

Specializations: General Track

Prerequisites: Fundamentals of Computers, Web Technologies

Course Description: This course will help students to learn about electronic commerce concepts, applications of electronic commerce, types of electronic commerce, how people, organization and industries take benefits from electronic commerce. role of electronic commerce in our daily life.

Aims and Objectives: When students complete this course, they will be able to:

- Understand electronic commerce transactions.
- Electronic ecommerce models.
- Business life cycle.
- Credit card, debit card and visa cards transactions.
- How to protect from Fraudulent activities on the web doing businesses.
- On-Line banking.
- To design and allow students to gain firsthand experience in studying and developing real-world systems for e-commerce.

Course Contents: Principles of E-Commerce. Origin and Growth of E-Commerce. Technologies for Development of E-Commerce Applications. Business Models and Strategies, Legal Issues Related to E-Commerce, Information Security, Information and Communication Technology. Security Infrastructure, Transaction Processing System, Secure Electronic Transactions, Sequence of Events for Tansactions, Visa Transaction Life Cycle, Visa Authorization Process, Card Not Present Transactions Requirements and Tips, CVS Information, Digital Certificate, X.509 Standard, Contents and Structure of Digital Certificate, Digital Certificate and Website Security, Digital Signature. HTTPS, SSL, TLS, Blind

Signature, Digital Cash, Electronic Funds Transfer. Financial Transactions, Electronic Money, Electronic Payment System, Electronic Bill Payment, Peer-to-Peer Payment System, Paypal, Online Banking Scrip, E-Business Models, Portal Sites, Market Model, E-Payment and Key Issues in E-Payment Systems, Types of E-payments, Effective E-Business Process, Customer Relationship Management, Analytical CRM, Customer Interactions, Operational CRM, Personalization. Supply Chain Management, Demand Management, Inbound/Outbound Logistics, Supply Management, Core Operations, Claims Processing, Internet and B2B, M-businesses, Internet or Electronic Marketing, E-Marketing Management, Steps in E-Marketing & Business Management. E-advertising, Banner Ads, Buying and Selling Space on the Web. Pay-per-Thousand, Pay-per-Click, Pay-per-Lead, Pay-per-Sale, Exchanging Space for Ads. Search Engine, Anatomy of Search engine, Registering Website with Search Engines, Domain, Types of Domains, Types of Queries for Sites. Business Life Cycle, Stages of Business Life Cycle. **Cross-Border E-commerce Concepts. Omni Channel Retail, Ecommerce Logistics Companies.** Entrepreneurship through E-Commerce.

Recommended Books

1. Deitel, H. M., Deitel, P. J., & Nieto, T. R. (2001). *e-Business & e-Commerce: how to program (Latest ed.)*. Prentice Hall.
2. Reynolds, J., & Mofazali, R. (2004). *The complete e-commerce book: design, build, and maintain a successful web-based business (2nd Ed.)*. Cmp Books.

Course Code	Course Title	Credit Hours
CS6705	Expert Systems	3(3+0)

Specializations: Artificial Intelligence, Database Systems

Prerequisites: Artificial Intelligence

Course Contents: Introduction, The Principles of operation of expert systems, State transition model: Expert system models: Planning actions, solving a problem, diagnosis, Producing advice; how to backtrack; a structure for expert system. The structure of state

spaces: connectivity, form; the implicit description of state spaces; search: depth and breadth first search. Functions for handling lists: functions for search; best first search. Eliciting knowledge from on expert: interviewing, examples, problem solving, psychological techniques. Knowledge representation schemes: rules, semantic nets, logic, frames. Some existing expert systems: MYCIN, DENDRAL, MACSYMA, PROSPECTOR. Characteristics of knowledge-bases systems, features of problem solvers, Architectural principals. The choices of system (language/package) production pit falls.

Recommended Books

1. Marshall, G. (1990). *Advanced Students' Guide to Expert Systems (Latest ed.)*. Heinemann Newnes Publications, Oxford.

Course Code	Course Title	Credit Hours
CS6706	Introduction to Parallel Computing	3(3+0)

Specializations: General Track

Prerequisites: Advanced Programming, Computer Organization and Architecture

Course Description: Single processor systems have become obsolete and the future of computing is in Parallelism. This course is an introductory course on parallel computing. It covers both the hardware and software aspect of parallel computing along with a discussion on parallel algorithms.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand the basic concepts of parallel computing.
- Understand the parallelism available at the hardware level.
- Understand how to design parallel algorithms and write simple parallel programs.

Course Contents: Introduction to Parallel Computing and its Importance, Concurrent Processes Basic Concepts of Concurrency, Concurrency in Operating Systems, Problems in Concurrent Programming, Basic Models of Parallel Computation, Shared Memory Model and Examples, Network Model and Examples, Parallel Algorithms, Evaluation of Parallel Algorithms, Amdahl's Law, Gustafson-Barsis's Law, Karp-Flatt Metric, Algorithms for Shared Memory and Network Models, Parallel Algorithms for Shared Memory, Parallel Algorithms for Network Models, Designing Parallel Algorithms, Steps of Designing, Problem Decomposition, Granularity of Computation, Minimizing Overheads, Task Allocation and Load Balancing, Parallel Architectures (Multi-cores, Multiprocessors, Heterogeneous Systems with Graphical Processing Units), Unconventional Architectures, Message-passing Programming and Examples, Shared Memory Programming and Examples.

Recommended Books

1. Czech, Z. J.(2017). *Introduction to Parallel Computing (Latest ed.)*, Cambridge University Press.

Bibliography

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

Course Code	Course Title	Credit Hours
CS6721	Information Architecture	3(3+0)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Web Technologies

Course Description: The post-AJAXian Web 2.0 world of wikis, folksonomies, and mashups makes well-planned information architecture even more essential. How to present large volumes of information to people who need to find what they're looking for quickly? This course will enable information architects, designers, and web site developers to build large-scale and maintainable web sites that are appealing and easy to navigate. This course will cover emerging technologies with recent examples, new scenarios, and information on best practices.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the fundamental components of an architecture, illustrating the interconnected nature of these systems.
- Know about the latest concepts of the social web including Tagging, Folksonomies, Social Classification, and Guided Navigation.
- Understand the tools, techniques, and methods that takes from research to strategy and design to implementation.
- Series of short essays that provide practical tips and philosophical advice for those who work on information architecture.
- Business context of practicing and promoting information architecture, including recent lessons on how to handle enterprise architecture.
- Case studies on the evolution of large information architectures, illustrating best practices along the way.

Course Contents: Role of Information Architect, Collaboration and Communication, Organizational Challenges, Creating Cohesive Organization Systems, Browser Navigation Features, Types of Navigation Systems, Building Context, Improving Flexibility, Effective Labeling Systems, Types of Labeling Systems, Searching and Websites, Designing Search Interface, Indexing Right Stuff, Metaphor Exploration, High-Level Architecture Blueprints, Architectural Page Mockups, Design Sketches, Web-based Prototypes, Content Mapping, Web Page Inventory, Architecture Style Guides, Thesauri, Controlled Vocabulary, Metadata, Information Architecture Strategy, Information Architecture and Business Strategy, Tools and Software.

Recommended Books

1. Rosenfeld, L., & Morville, P. (2015). *Information architecture for the Web and Beyond (4th Ed.)*. O'Reilly Media, Inc.
2. Governor, J., Hinchcliffe, D., & Nickull, D. (2009). *Web 2.0 Architectures: What entrepreneurs and information architects need to know (Latest ed.)*. O'Reilly Media, Inc.

3. Rosenfeld, L., & Morville, P. (2006). *Information architecture for the world wide web (Latest ed.)*. O'Reilly Media, Inc.

Course Code	Course Title	Credit Hours
CS6722	Web Content Management Systems	3(2+1)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Web Technologies

Course Description: Advancement in information technologies, especially the in the area of World Wide Web (WWW) enabled companies and individuals to expend their businesses by developing attractive websites. In a rapidly changing world, the need for online publishers to keep up with the needs and expectations of their site visitors is paramount. Today, many web publishers use content management systems (CMS) to allow them to instantly and dynamically update web pages and properties as new content becomes available so that every visit to a site is engaging, informative, and meaningful. This course explores the use of the three most popular open source web-based content management systems—WordPress, Joomla, and Drupal—to create dynamic and flexible websites and landing pages. Students explore the fundamentals of planning dynamic websites, CMS database management, developing CSS-controlled site templates, and creating database-driven websites through the planning and creation of their own topic-based sites.

Aims and Objectives: When students complete this course, they will be able to:

- Introduce learners to the three most popular open source content management systems (CMS) in use on the web today, including WordPress, Drupal, and Joomla.
- Understand the difference between a CMS website, a static website, and websites using other server-side technologies.
- Understand the benefits of working with a server-side database and the power it brings to creating and managing websites.
- Compare and contrast the three most popular open source CMS.
- Create and deploy websites using CMS, including creating and editing content, adding functionality, and creating custom templates and themes.
- Understand ongoing maintenance considerations with CMS websites.
- Help in freelancing and outsourcing.

Course Contents: Contents, Contents Management, Implementing Content Management Solutions, Introduction to WordPress, Extending WordPress, WordPress Theming, Introduction to Joomla, Extending Joomla, Custom Joomla Templates, User management and permissions, Introduction to Drupal, Extending Drupal Content, Extending Drupal Functionality via Modules, Creating Lists of Content with Views, Custom Theming.

Recommended Books

1. Hackos, J. T. (2002). *Content management for dynamic Web delivery (Latest ed.)*. John Wiley & Sons, Inc..
2. Barker, D. (2016). *Web Content Management: Systems, Features, and Best Practices (Latest ed.)*. O'Reilly Media, Inc.
3. Glaman, M. (2016). *Drupal 8 Development Cookbook (Latest ed.)*. Packet Publishing Ltd.
4. Williams, A. (2017). *WordPress for Beginners 2017: A Visual Step-by-Step Guide to Mastering WordPress (Latest ed.)*. CreateSpace Independent Publishing Platform.
5. Burge, S. (2011). *Joomla! Explained: Your Step-by-step Guide (Latest ed.)*. Pearson Education.

Course Code	Course Title	Credit Hours
CS6723	Web Engineering	3(3+0)

Specializations: Web Engineering, Software Engineering, General Track

Prerequisites: Advanced Programming, Web Technologies, Software Engineering

Course Description: The World Wide Web has become a major delivery platform for information resources. Many applications continue to be developed in an ad-hoc way, contributing to problems of usability, maintainability, quality and reliability. Web Engineering introduces a structured methodology 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.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the concepts, principles and methods of Web engineering.
- Apply the principles, and methods of Web engineering to Web applications development.
- Analyze and design comprehensive systems for the creation, dissemination, storage, retrieval, and use of electronic records and documents.
- Learn techniques and evaluation metrics for ensuring the proper operability, maintenance and security of a web application.
- Apply the web engineering methodologies for web application development

Course Contents: 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 (Requirements, Content, Hypertext, Presentation, and Customization), Design Guidelines, Web Usability Engineering Methods, Web Usability Engineering Trends, Client/Server Communication on the Web(SMTP, RTSP,HTTP, Session Tracking), Client-side Technologies, Document-specific Technologies (HTML, SVG, SMIL, XML), 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 the Development Process of a Web Application.

Recommended Books

1. Chopra, R. (2016). *Web Engineering (Latest ed.)*. PHI Learning Pvt. Ltd.
2. Suh, W. (2005). *Web Engineering Principles and Techniques (Latest ed.)*. Idea Group Publishing.
3. Pressman, R., & Lowe, D. (2009). *Web Engineering: A Practitioners Approach (Latest ed.)*. McGraw-Hill.

Course Code	Course Title	Credit Hours
CS6731	Routing and Switching	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: This course is a study of Routing and Switching fundamentals, and how the Internet is integrated into the computing environment to enable organizations to share resources, collaborate, and meet organizational goals. In the Computer Networks essentials and the creation of simple Local Area Networks (LANs) introduced, Networking Technologies, are expanded upon to incorporate the linking of these simple networks to each other and to the Internet, to create an internetwork. Routing and Switching devices such as switches and routers will be examined in great detail. Students will focus on techniques to analyze, plan, and manage an enterprise network. In support of these techniques, lab activities will include sub-netting, packet-sniffing, and switch and router configuration.

Aims and Objectives: When students complete this course, they will be able to:

- Configure and subdivide an IP network.
- Differentiate between routable, non-routable, and routing protocols. Differentiate between Exterior Gateway Protocols and Interior Gateway Protocols. Configure static routing and default routes. Configuration of RIP v1, RIP v2, OSPF, IGRP, EIGRP, BGP routing protocols.
- Use advanced routing concepts such as CIDR, summarization, and VLSM.
- Identify the differences between IPv4 and IPv6 5.
- Configure a router dealing with modes, prompts, passwords, context-sensitive help, and enhanced editing feature.
- Configure HyperTerminal to access routers and switches.
- Manipulate the router boot process.
- Use Cisco Discovery Protocol.

Course Contents: IP Addressing, Subdividing IP Classes, Variable Length Subnet Masks, Working with Hexadecimal Numbers e. IPv4 vs. IPv6, Basic of IOS, Benefits of Routing, Cisco Router User Interface, Router Components, Router Startup, IP on the Router, IP Connectivity, CDP, Cisco IOS, Router Password Recovery, Security Device Manager, Non-routable protocols, Routed Protocols, Routing Protocols, Routing Information Protocol, Interior Gateway Routing Protocol, Open Shortest Path First, Static Routing, Classful and Classless Routing Protocols, Routing Information Protocol version 2, Enhanced Interior Gateway Routing Protocol, Open Shortest Path First, OSPF Authentication, Controlling Route Traffic, Network Address Translation, Configuring Network Address Translation, Domain Name System, Dynamic Host Configuration Protocol, Security Device Manager, Benefits of VLANs, Static vs. Dynamic VLANs, VLAN configuration, VLAN Trunking Protocol (VTP), Access List: Usage and Rules, Standard IP Access Lists, Extended IP Access Lists, Using Named Lists,

Controlling VTY Line Access, Using Security Device Manager to Create Access Control Lists, Using Security Device Manager to Create a Router Firewall, Boarder Gateway Protocol.

Recommended Books

1. Lammle, T., Tedder, W. (2014). CCNA *Routing and Switching Deluxe Study Guide (Latest ed.).* John Wiley & Sons Ltd..
2. Empson, S. (2008). *CCNA Routing and Switching Portable Command Guide (Latest ed.).* Cisco Press.
3. Puzmanova, R. (2002). *Routing and Switching: Time of Convergence? (Latest ed.).* Addison-Wesley.

Course Code	Course Title	Credit Hours
CS6732	Internet of Things	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Programming Fundamentals, Computer Networks

Course Description: The module is designed to provide students with a solid technical introduction to the Internet of Things (IoT). The course is broadly divided into two parts, namely development at the edge and development in the cloud. A systems engineering approach is adopted reviewing the key technologies employed at different levels of the IoT stack and how they are integrated to form complete IoT systems.

Aims and Objectives: When students complete this course, they will be able to:

- To introduce students to the concepts underlying the Internet of Things (IoT).
- To provide overview list of popular protocols and standards helping power IoT devices, apps and applications.
- To introduce devices including sensors, low power processors, hubs/gateways and cloud computing platforms.

Course Contents: Introduction to IOT and Importance, Elements of IoT Ecosystem, Technology Drivers, Business Drivers, Typical IoT Applications, IoT Protocols and Development Platforms(Arduino, Raspberry Pi, Particle Core, Electric Imp, Pinoccio), Advantages and Disadvantages, Fast, Reliable, Lightweight and Bidirectional Characteristics of IoT Protocols, Protocols such as HTTP, Web sockets and Message Queuing Telemetry Transport (MQTT) Protocols in addition to Nano IP, Content Centric Networking (CCN), Time Synchronized Mesh Protocols (TSMP), MQTT-SN (Sensor Networks), CoAP and Related Protocols, Trends, Implications and Future of IoT, Current Challenges to the IoT, How IoT Devices Interact with each other, Sensing Devices Sensor Modules, Nodes and Systems, Wireless Technologies for the IoT, Edge Connectivity and Protocols, Fundamental Concepts of Sensor Network Design, Sensor Network Software and Hardware, Sensor Network Protocols, Mechanisms, Algorithms to Implement Sensing Systems, Program and Experiment with Sensors, Signal Processing, Real-Time and Local Analytics, Databases, Cloud Analytics and Applications, Industry Perspective - Business Considerations, Legal Challenges, Local Processing on the Sensor Nodes, Understanding Privacy Implications and Security Issues in IoT, Mini-project.

Recommended Books

1. Biron, J., Follett, J. (2016). *Foundational Elements of an IoT Solution (Latest ed.)*. O'Reilly Media.
2. Keysight Technologies (2016). *The Internet of Things: Enabling Technologies and Solutions for Design and Test (Latest ed.)*. Application Note.
3. Bell, C. (2013*). Beginning Sensor Networks with Arduino and Raspberry Pi (Latest ed.)*. Apress.

Course Code	Course Title	Credit Hours
CS6733	Network Programming	3(3+0)

Specializations: Computer Networks, General Track

Prerequisite: Computer Networks, Advanced programming

Course Description: This course focuses on the network programming. This course will help understand the students about all the networking concepts, their working and applications.

Aims and Objectives: When students complete this course, they will be able to:

- Analyse the requirements of a networked programming environment and identify the issues to be solved.
- Create conceptual solutions to those issues and implement a programming solution.
- Understand the key protocols that support the Internet.
- Apply several common programming interfaces to network communication.
- Understand the use of TCP/UDP Sockets.

Course Contents: Network Programming Skills and Concepts, Covers Application Layer Protocol and How Applications Use the Transport Layer, Principles and Practice of Network Programming; The Client-Server Model, Concurrent Processing, Introduction to Client and Server Software Design with Examples, Principles, Issues and Challenges in E-mail and Web Application Protocols; Security Protocols; and Network Life System Concepts, Unix Programming Environment, TCP Protocol Suit, Socket Programming, Implementation of Communication Protocols Including HTTP, I/O Multiplexing including Non-blocking I/O, Advanced Socket Options, Name and Address Conversions, IPv4 and IPv6 Interoperability, Unix Domain Protocols, Broadcasting and Multicasting, Routing and Communication, Pipes and FIFO's Message Queues, Implementation of Mutexes, Spins, Binary and Counting Semaphores, POSIX Shared Memory, Doors and RPC (Remote Procedure Calls).

Recommended Books

1. Ciubotaru, B., Muntean, G. (2013). *Advanced Network Programming (Latest ed.).* Springer Science & Business Media.
2. Reid, F. (2004). *Network programming in .NET (Latest ed.).* Digital Press.
3. Harold, E. R. (2013). *Java Network Programming (Latest ed.).* O'Reilly Media.

Course Code	Course Title	Credit Hours
CS6734	Wireless and Mobile Networks	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: Wireless and mobile networking is one of the fastest growing segments of the computer industry. Wireless network has been around for many years and it has already started to dominate the wired network. This course is focused on the introduction and fundamental concepts about wireless and mobile networks. Students will be able to understand how wireless standards and protocols are developed. Furthermore, students will be exposed to the history and future trends in wireless and mobile technologies.

Aims and Objectives: When students complete this course, they will be able to:

- The fundamental concepts about the wireless and mobile networks.
- The techniques in the design and operation of wireless networks.
- Students will be able to survey the breadth of wireless and mobile devices and protocols in commercial use today.
- The students will be familiar with the wireless networks, its configuration and use.

Course Contents: Principles of Wireless Communication, Wireless Networks, Main Components of a Wireless System, Modes of Operation Infrastructure Mode, ad-hoc Mode, Compatibility of Different Technologies, Nyquist-Shannon Sampling Theorem, Nyquist Bandwidth, Signal-to-Noise Ratio, Multiplexing, Antenna and Types, Modes of Propagation, Radio Channel Characterization, Multipath Propagation, co-channel Interference, Exponential Power Delay Profile, Propagation Effects - Scattering, Ground Reflection, Fading, Log-normal Shadowing, Rayleigh & Rician Fading, Coherence Bandwidth, PHY Layer Techniques, Wideband Modulation Techniques to CPE with Inter-symbol Interference (Diversity, Spread Spectrum, Frequency Hopping, Direct Sequence, Adaptive Equalization, and Orthogonal Frequency Division Multiplexing), Components of a Satellite-based Network, Multiple Access Techniques (FDMA, TDMA and CDMA, CSMA/CA and Slotted Aloha), Orthogonal and Non-orthogonal Multiple Access (NOMA), Cellular Concepts, Sectorization and Cell Splitting, Handover and Types, Frequency Reuse, Reuse Distance, Cluster Size, Channel Assignment Strategies, Handoff Strategies, co-channel Interference and System Capacity, Trunking and Grade of Service, Mobile Network Generations (1G, 2G, 3G, 4G and 5G Concepts), Wireless Local Area Networks (WLANs), 802.11 Networks and Versions (802.11 a, b, g, n), ad-hoc Wireless Personal Area Networks (WPANs), Bluetooth Standard 802.15 and Version, Infrared Communication, Femtocells, Multi-hop Relay Networks, Wireless Mesh Networks, Homogeneous and Heterogeneous Networks, Integration and Challenges, Coordinated Multipoint (CoMP) and Cooperative Communication Concepts and Advantages.

Recommended Books

1. Stallings, W. (2013). *Wireless Communications & Networks (Pearson New International Ed.)*. Pearson Education Limited.
2. Molisch, A. F. (2010). *Wireless communications (Latest ed.)*. Wiley.
3. Rappaport, T. S. (2002). *Wireless communications: Principle and Practice (2nd Ed.)*. Prentice Hall.
4. Tanenbaum A. S. (2002). *Computer Networks (4th Ed.)*. Prentice Hall.

Bibliography

1. Schiller, J. (2013). *Mobile communications (2nd Ed.)*. Addison-Wesley.
2. Goldsmith, A. (2005). *Wireless Communications (Latest ed.)*. Cambridge University.

Course Code	Course Title	Credit Hours
CS6741	Advanced Database Systems	3(3+0)

Prerequisites: Database Systems, Software Engineering, General Track

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

Aims and Objectives: When students complete this course, they will be able to:

- Understanding of advanced concepts in database systems.
- Discuss and evaluate methods of storing, managing and interrogating complex data.
- Explain and evaluate the fundamental theories and requirements that influence the design of modern database systems.

Course Contents: Advanced Normalization, Multi-Valued Functional Dependency, Database Security, Possible threats to database, Computer-Based Counter Measures, Authorization and Authentication, Access Controls, Backup and Recovery, Views, Integrity

Constraints, Encryption, RAID, Database Concurrency, Transactions and Its ACID Properties, Anomalies due to concurrent execution of transaction and Concurrency Control, Serializability, Lock-Based Concurrency Control, handling Deadlocks in concurrency, Time-Stamping technique for concurrency control, Optimistic Methods, Granularity of Data Items, Database Recovery, Transactions and Recovery, Recovery Facilities (Backup, Log File, Check-Pointing), Recovery Protocols, Deferred Updates, Immediate Updates, Shadow Paging, Query Optimization Techniques (Join Ordering, Nested Query Planning, Cost Estimation), Distributed Databases, DDBMS, Homogeneous vs. Heterogeneous DDBMS, Distribution Transparencies, Distributed Database Design, Data allocation, Fragmentation, Object Oriented Database and OODBMS, Comparison of OO Data Modeling vs. Conceptual Data Modeling

Text Book

Coronel, C., & Morris, S. (2016). *Database systems: design, implementation, & management (Latest ed.)*. Cengage Learning.

Bibliography

1. Ramakrishnan, R., & Gehrke, J. (2003). *Database Management Systems (3rd Ed.)*. WCB/McGraw Hill.
2. Elmasri, R., & Navathe, S.B. (2016). *Fundamentals of Database Systems (Global Ed.)*. Pearson Education Limited.
3. Hoffer, J., Venkataraman, R., & Topi, H. (2015*). Modern database management (Latest ed.)*. Prentice Hall Press.
4. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). *Database system concepts (4th Ed.)*. New York: McGraw-Hill.
5. Garcia-Molina, H. (2008). *Database systems: the complete book (Latest ed.)*. Pearson Education India.

Course Code	Course Title	Credit Hours
CS6742	Fundamentals of Data Warehousing	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Database Systems

Course Description: The primary focus of this course is on the basic concept of Data Warehousing. The course concentrates on topics like: Planning and requirements gathering for data warehousing, data warehouse architecture, dimensional model design for data warehousing, extracting, transforming, and loading strategies.

Aims and Objectives: Students successfully completing this course should be able to:

- Overview of a data warehouse development project, and identify key factors in the success or failure of such projects.
- Identify key data warehousing products, services, tools and consultancy requirements.
- Implement key features of a data warehouse within popular relational DBMSs.

Course Contents: Introduction to Data Warehousing and Decision-Support Systems, Operational vs Informational Systems, online transaction processing (OLTP) and online analytical processing (OLAP), Data Warehouses and Data Marts, Building Blocks and Components of Data warehousing, requirements and planning, requirements gathering methods and information package, Introduction to the Dimensional Model (Facts, Dimensions, Star schema, Snowflake schema), aggregated fact tables, De-normalization, The Architectural Plan, Data Storage Specifications, Data Design, Levels of Detail, Information Delivery Strategy, Role of Metadata and Metadata Types by Functional Areas as Data Acquisition, Data Storage, Information Delivery, Data Warehouse Queries, Extract Transform Load (ETL), MDX Query, Multidimensional data (Cube).

Recommended Books

Kimball, R., & Ross, M. (2011). *The data warehouse toolkit: the complete guide to dimensional modeling (Latest ed.)*. John Wiley & Sons.

Inmon, W. H. (2005). *Building the data warehouse (Latest ed.)*. John Wiley & sons.

Hammergren, T. C. (2009). *Data warehousing for dummies (Latest ed.)*. John Wiley & Sons.

Ponniah, P. (2004). *Data warehousing fundamentals: a comprehensive guide for IT professionals (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS6751	Usability Engineering	3(3+0)

Specializations: Software Engineering, Web Engineering, General Track

Prerequisites: Nil

Course Description: Usability engineering is integral to the design process of an individual software product or service in terms of how the end-users perceive and use that product or design. The objective of this course is to provide students an advanced understanding of the role of usability engineering in the software design process. The students will also have practical experience with tools and methods that are used as part of the usability engineering process.

Aims and Objectives: After completing the course, students should be able to:

- Understand the concept of usability engineering and its importance in software development.
- Learn the concept and apply techniques of usability engineering.

Course Contents: Usability Definitions, Justification for Usability, User Centered Design, Interaction Design, Users, Tasks, Usability Engineering, Interface Evaluation, Usability Methods, Usability Testing, Usability Data Analysis and Reporting, User Experience.

Text Book

1. Klein, L., & Rutter, K. (2016). *Build Better Products: A Modern Approach to Building Successful User - Cantered Products (1st Ed.)*. Rosenfeld Media.

Bibliography

1. Platt, D. (2016). *The joy of UX: User Experience and interactive design for developers (1st Ed..)*. Boston: Addison-Wesley.
2. Rubin, J. (2008). *Handbook of Usability Testing: How to Plan; Design; and Conduct Effective Tests (2nd Ed.)*. Wiley.

Course Code	Course Title	Credit Hours
CS6752	Computer Aided Software Engineering	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Advanced Programming, Software Engineering

Course Description: This course provides an overview of the professional development environment which accommodates different automation tools for different phases in a development process. *CASE* (*computer-aided software engineering*) is the use of a computer-assisted method to organize and control the development of software. The course puts emphasis on using a complete automated development environment including project management, team management, testing and build.

Aims and Objectives: After completing the course, students should be able to:

- Understand different perspectives for CASE tools classification.
- Understand the cost of using and building CASE tools.
- Use different CASE tools for each software development phase.
- Compare and contrast the fitness of existing CASE Tools to the needs of specific software development context.

Course Contents: Setting up a proper development environment, development environment vs staging, vs. production environment, need for a staging environment, concept of staging database, release management, sandbox, Fundamentals of project management, team management, source code management, configuration management and revision control, Development IDEs, Automated Testing, source code integration and continuous integration, automated build and deployment.

Recommended Books

1. Humble, J., & Farley, D. (2015). *Continuous delivery: reliable software releases through build, test, and deployment automation (1st Ed.)*. Upper Saddle River, NJ: Addison-Wesley.

Bibliography

1. Loeliger, J. (2012). *Version Control with Git: Powerful Tools and Techniques for Collaborative Software Development (Latest ed.)*. O'Reilly Media
2. Siriwardena, P. (2015). *Maven Essentials (1st Ed.)*. Packt Publishing
3. Sagar, R. (2015). *Mastering JIRA (1st Ed.)*. Packt Publishing.

Course Code	Course Title	Credit Hours
CS6753	Software Architecture and Design	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Software Engineering

Course Description: To understand importance of architecture in software development and to introduce general guidelines for software architecture design and quality requirements.

Aims and Objectives: When students complete this course, they will be able to:

- Understand fundamentals of software architecture.
- Understand quality requirements of a software system
- Understand fundamental principles and guidelines for software architecture design, architectural styles, patterns, and frameworks.
- Understand software architecture design and evaluation processes.

Course Contents: Introduction to the fundamentals of software architecture, Software architecture and quality requirements of a software system, Fundamental principles and guidelines for software architecture design, architectural styles, patterns, and frameworks, Methods, techniques, and tools for describing software architecture and documenting design rationale, Software architecture design and evaluation processes, Future challenges and emerging trends in software architecture discipline.

Recommended Books

1. Bass, L., Clements, P., & Kazman, R. (2013). *Software architecture in practice (3rd Ed.).* Upper Saddle River, NJ: Addison-Wesley.

Bibliography

1. Babar, M. A., Brown, A.W., & Mistrik, I. (2013). *Agile Software Architecture: Aligning Agile Processes with Software Architecture (Latest ed.)*. Morgen Kaufmann Publishers.

Course Code	Course Title	Credit Hours
CS6761	Natural Computation	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: Data Structures and Algorithms, Artificial Intelligence

Course Description: The aim of the course is to acquaint students with problems in search and optimization and give them a basic knowledge of the computational techniques used to solve such problems. The course focuses on heuristic methods and covers a spectrum of such methods including both population-based and single evolution method. The course aims to provide students working knowledge of GA, ACO, PSO, and other techniques for solving computationally hard problems. The objective is to enable students to apply the heuristic framework to practical problems.

Aims and Objectives: Upon completing this course,

- Students will have knowledge of search and optimization problems and their complexity, and the computational technique to solve them.
- They will understand the working of the heuristic methods and be able apply them to known optimization problems in resource allocation, routing, etc.

Course Contents: Search and optimization problem; Heuristic methods for search and optimization: local versus global search, single-evolution versus population based methods, hybrid and mimetic methods; Tabu search (TS); Simulated annealing (SA); reactive search optimization; Genetic Algorithms (GA): selection, recombination, and mutation, fitness and objective function, inversion, replacement, and other operators, crowding, niching, island, and cellular models, the schema theorem; Ant Colony Optimization (ACO); Particle Swarm Optimization (PSO); Differential evolution; DNA computing; hybrid algorithms, mimetic algorithms, and pareto-optimization; application to travelling salesman, hub location, bin-packing, routing, and other problems.

Recommended Books

1. Sivanandam, S. N., & Deepa, S. N. (2007). *Introduction to Genetic Algorithms (Latest ed.).* Springer Berlin Heidalberg.
2. Mitchel, M. (1999). *An introduction to Genetic Algorithms (Latest ed.)*. MIT Press.
3. Negnevtsky, M. (2005). *Artificial Intelligence-A Guide to Intelligent Systems (2nd Ed.)*. Addison-Wesley.
4. ChengGuo., & Yang, X. *A programming of genetic algorithm in MATLA 7 (Latest Editoin).* Modern Applied Science.

Course Code	Course Title	Credit Hours
CS6762	Introduction to Neural Networks	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: and Data Structures and Algorithms, Advanced Programming, Calculus Analytical Geometry, Linear Algebra, Probability and Statistics

Course Description: This is a preliminary course in neural networks. The aim of the course is to introduce students to learning and pattern recognition techniques based on the neural network model. Learning objectives include enabling students to gain a knowledge of basic NN models based on single and multilayer perceptrons. Concept of self-organizing systems and competitive learning are introduced through the example of SOMs.

Aims and Objectives: When students complete this course, they will be able to:

- Implement neural networks based on single and multi-perceptron models and apply the models to the recognition and learning problems. Furthermore, they will have the basic knowledge to study the topic of NNs at advanced levels.

Course Contents: Human brain, models of a neuron, neural network architecture, knowledge representation, the learning process, hebbian learning, memory-based learning, competitive learning, Bltzaman learning, memory, adaption, statistical learning theory; Single-layer perceptrons: adaptive filtering problems, unconstrained optimization techniques, linear least square filters, least-mean square algorithms, learning curves, learning rate annealing techniques, perceptron, perceptron convergence theorem; Multi-layer perceptron: back-propagation algorithm, XOR problem, feature detection, back-propagation and differentiation, strengths and limitations of back-propagation; Self-organizing maps: feature-mapping models, the SOM algorithm, properties of feature map.

Recommended Books

1. Haykin, S., & Network, N. (2004). *A comprehensive foundation. Neural Networks (2nd Ed.)*. Pearson Education, Pearson Printice-Hall.
2. Sivanandam, S. N., & Deepa, S. N. (2006). *Introduction to neural networks using Matlab 6.0 (Latest ed.).* Tata McGraw-Hill Education.

Semester VIII

Courses

Course Code	Course Title	Credit Hours
CS6801	Natural Language Processing	3(3+0)

Prerequisites: Artificial Intelligence

Course Description: This course covers the introduction to Natural language Processing. Natural language processing (NLP) is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages and, in particular, concerned with programming computers to fruitfully process large natural language corpora.

Course Contents: Monolingual Natural Language Processing: Difference between natural and formal languages. Natural language understanding: syntax, semantics, phonetics, morphology, discourse analysis. anaphora/cataphora, cohesion/coherence, ellipses, ambiguity (structural, lexical, transient, discourse).Natural language Generation: steps in generation. Natural Language Interfaces. Machine Translation: Translation steps: analysis, transfer and generation. Translation Strategies: direct translation, interlingua and transfer. Types: Bilingual, Multi-lingual. Dictionary design: monolingual, bilingual. Units of translation: word, sentence, discourse. Some operational and R&D machine translation systems. Speech translation, benefits of machine translation, integration of machine translation to other fields of computer science, Urdu, Pashto and machine translation. Natural language processing and computational social sciences. Natural language process and journalism, sentiment analysis and opinion mining.

Recommended Books

1. Khan, M. A. (1995). *Text Based Machine Translation (Latest ed.)*.
2. Jurafsky, D., & James, H. (2000). *Speech and language processing an introduction to natural language processing, computational linguistics, and speech (Latest ed.)*. Pearson Education Inc.
3. Manning, C. D., & Schütze, H. (1999). *Foundations of statistical natural language processing (Latest ed.)*. Cambridge MIT press.
4. Indurkhya, N., & Damerau, F. J. (Eds.). (2010). *Handbook of natural language processing (Latest ed.)*. Chapman and Hall/CRC.

Course Code	Course Title	Credit Hours
CS6802	Professional Practices	3(3+0)

Prerequisites: Nil

Course Description: The aim of this module is to help students develop an understanding of the fundamental professional, ethical, and legal issues and how they are being developed and applied.

Aims and Objective: When students complete this course, they will be able to:

- Understand the concepts of key, ethical, managerial and legal issues typically encountered by an IT professional.
- Identify, access and critically review appropriate and relevant literature drawn from academic, technical, legal, professional business sources.
- Evaluate and critically reflect upon self-presentation.
- Work with others.

Course Contents: 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 and Misuses, and Risks of Software, Information Security and Privacy, Business Practices and Economics of Software, Intellectual Property and Software Law (Cyber Law), Social Responsibilities, Software Related Contracts, Software House Organization.

Recommended Books

1. Bott, F., Coleman, A., Eaton, J., & Rowland, D. (2000). *Professional issues in software engineering (Latest ed.)*. CRC Press.
2. Bott, F. (2014). *Professional issues in information technology (2nd Ed.)*. BCS Learning & Development Limited.

Eighth (8th) Semester Specializations Elective Courses

Course Code	Course Title	Credit Hours
CS6804	**Computer Graphics and Imaging**	**3(2+1)**

Specialization: General Track, Pattern Recognition

Prerequisites: Linear Algebra, Object Oriented Programming

Course Description: This is a beginning course in computer graphics and imaging. The focus is on computational geometry, animation, and simulation. Various issues in graphics and imaging are discussed and mathematical concepts to model and deal with them are introduced.

Aims and Objectives: After completing this course:

- Students will have knowledge of the issues and solutions in computer graphics and will be able to handle such graphing tasks such as designing interactive video games and games for mobile devices.

Course Content: Creating Images with OpenGL, Mathematical Concepts: Triangles, Normals, Interpolation. Concept of Light and Color and Impact on Display and Printer, Scanline Rendering, OpenGL Pipeline, Triangles, Rasterization, Transformations, Shading, Triangle Meshes, Subdivision, Marching Cubes, Textures, Light, Color, Cameras, Displays, Tone Mapping, Lighting Equation, Global Illumination, Radiosity, Ray Tracing, Acceleration Structures, Sampling, Antialiasing, Reflection, Transmission, Depth of Field, Motion Blur, Monte Carlo, Bidirectionalr Ray Tracing, Light Maps.

Recommended Books

1. Marschner, S., & Shirley, P. (2015). *Fundamentals of Computer Graphics (4th Ed.)*. AK Peters/CRC Press.
2. Shreiner, D. (2013). *OpenGL Programming Guide: The Official Guide to Learning OpenGL, Version 4.3 (8th Ed.)*. Addison-Wesley Professional.
3. Munshi, A., Gisburg, D., & Shreiner, D. (2008). *OpenGL ES 2.0 Programming Guide (1st Ed.)*. Addison-Wesley Professional.

Referece Books

1. Ableson, W. F., Sen, R., King, C., & Ortiz, C. E. (2011). *Android in action (3rd Ed.)*. Manning Publications.
2. Conway, J. & Hillegass, A. (2012). *iOS Programming: The Big Nerd Ranch Guide (3rd Ed.)*. Big Nerd Ranch Guides.

Course Code	Course Title	Credit Hours
CS6805	Numerical Computing	3(2+1)

Specialization: General Track

Prerequisites: Calculus and analytic Geometry, Multivariate Calculus, Linear Algebra.

Course Description: The course introduces numerical computational methods for various mathematical operations. Numerical techniques for computing integrals, performing differentiation, and solving linear and non-linear equations are covered.

Aims and Objectives: After covering this course:

- Students will be able to implement different numerical computational techniques and think of their applications in computer science.

Course Content: Error Analysis: Definition of Errors, Effect of Rounding Errors, Evaluation Functions. Solving Non-Linear Equations, Linear System of Equations and Methods for Solution, Finite Differences: Difference Table, Difference Operators and Relationship Between Difference Operators, Interpolation: Formulas and Error Estimation in Interpolation, Numerical Differentiation and Formulas for Numerical Differentiation, Numerical Integration: Simpson's, Trapezoidal, Boole's Rules, Weddle's Rule, Newton-cotes Formulas, Repeated use of Trapezoidal Rule, Romberg's Integration Method, Ordinary Differential Equations and Methods for Solution, Taylor Series and Euler's Method, Runge-Kutta and Predictor-corrector Methods, Solving Higher Order Differential Equations.

Recommended Books

1. Burden, R..L., & Douglas, F. J. (1993). *Numerical Analysis (5th Ed.)*. PWS-KENT Publishing Company.
2. Hamming, R. W. (1987). *Numerical methods for scientists and engineers (2nd Ed.)*. Dover Publications.
3. Karris, S. T. (2007). *Numerical analysis using MATLAB and Excel (3rd Ed.)*. Orchard Publications.

Course Code	Course Title	Credit Hours
CS6806	Digital Image Processing	3(3+0)

Specializations: Pattern Recognition, General Track

Prerequisites: Calculus and Analytical Geometry, Linear Algebra, Artificial Intelligence

Course Description: 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.

Aims and Objectives: After completing this course,

- Students would have a basic understanding of the issues involved in image processing and the approaches, algorithms, and tools used to solve them.
- Students are able to compare and evaluate different approaches, and think about alternate solutions.
- Students are able to apply existing techniques to practical problems and undertake an undergrad level project in the area of image processing.

Course Contents: 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.

Recommended Books

1. Gonzales, R. C., & Woods, R. E. (2008). *Digital Image Processing (3rd Ed.)*. Pearson Printice-Hall.

2. Gonzales, R. C., Woods, R. E. & Eddins, S. L. (2004). *Digital Image Processing using MATLAB (2nd Ed.)*. Pearson-Prentice-Hall.
3. Efford, N. (2000). *Digital Image Processing (Latest ed.)*. Addison Wesley.

Course Code	Course Title	Credit Hours
CS6807	Telecommunication Systems	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Computer Networks

Course Description: This course will focus on theoretical frameworks and fundamental concepts behind the design and analysis of telecommunication networks (voice and data). Various algorithmic and optimization techniques used for efficient functioning of modern telecommunication networks will be taught.

Aims and Objectives: When students complete this course, they will be able to:

- Basic components of telecommunication systems.
- The challenges involved in guaranteeing QoS in telecommunication system.
- Different algorithms and processes involved in the design and management of telecommunication system.

Course Contents: Overview, Models and Why We Develop and Use Them, Terminology, Taxonomies of Telecom Systems, Analog and Digital Signals, Noise, Time and Frequency Domains of Signals, Modulation, Synchronous and Asynchronous Transmission, Transmission Subsystems, Transmission Media, Analog and Digital Transport Subsystems, Basic Concepts of Switching, Space and Time Division Switching Networks, ATM and Frame Relay, Store-and-Forward Switching, Characteristics of Switching Equipment and Systems, Examples of Switching Systems, Control Concepts and Definitions, Characteristics of Signaling Mechanisms, Examples of Signaling Subsystems, Network Management Concepts, Primary and Supplementary Access Functions, Simple Telecommunication Systems, Public Switched Telephone Network, Other Telecom Systems such as GSM, Network Services, Network Simulations using MATLAB, Graph Models of Networks, Fundamental Graph Algorithms, Network Optimization Techniques, Centralized and

Distributed Network Topology Design, Traffic Characterization, Delay Modeling, Resource Management, QoSIssues and Congestion Control, Routing and Multicasting, Network Reliability, Capacity Planning, Access Network and Backbone Network Design, Stochastic Processes, Queuing Analysis, Flow Analysis, Performance Modeling and Simulation, Optical Network Design.

Recommended Books

1. Devetak F. U., Bosse, J. G. V. (2006). *Signalling in Telecommunication Networks (Latest ed.).* John Wiley & Sons.
2. Ayers, M. L. (2012). *Telecommunications System Reliability Engineering, Theory and Practice (Latest ed.).* John Wiley & Sons.
3. Terré, M., Pischella, M., Vivier, E. (2013). *Wireless Telecommunication Systems (Latest ed.).* John Wiley & Sons.

Bibliography

1. Lakatos, L., Szeidl, L., Telek, M. (2012). *Introduction to Queuing Systems with Telecommunication Applications (Latest ed.)*. Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS6808	Network Security	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Data Communication, Computer Networks

Course Description: This course helps students to learn about cryptography, network security, the need to protect computer networks from unauthorized users and to exercise personal freedom on the network.

Aims and Objectives: When students complete this course, they will be able to:

- Understand network security.
- Services of network security.

- Types of techniques used for network security.
- Secret key cryptography and public key cryptography.
- Message authentication codes.
- Firewalls and protections of sensitive information.

Course Contents: Introduction of Network Security, Cryptography, Cipher , Key, Plain text, Cipher Text, Encipher , Decipher, Services of Cryptography, Ceaser cipher, Types of Cryptography, Secret Key Cryptography, Public Key Cryptography, Message Digest, Famous Algorithm of Secret Key Cryptography, Data Encryption standard, Initial Permutation in DES, Final Permutation in DES. DES round for Encryption, DES round for Decryption, Per-round key generation, Using Secret key cryptography to encrypt messages larger than 64-bits, Electronic Code Book, Cipher block Chaining, Output Feedback Mode, Cipher Feedback Mode, International Data EncryptionAlgorithm (IDEA), Multiple Encryption through DES i.e. Triple DES, Advanced Encryption Standard(AES), Modular Arithmetic, Public Key Cryptography, Congruence, Totient Function, Types of Public Key Cryptography, RSA Algorithm and examples, Deffie-Hellman Algorithm and examples, Step in Deffie-Hellman Algorithm for PKI. Trusted Intermediaries, Key Distribution Center/Key management Center, Digital Certificate, Certifying Authority, Certificate Revocation List, Firewall, Types of Firewalls. Kerberos protocol Working process, Privacy Enhanced Mail , Digital Watermarking, Identity Based Cryptography, Bilinear Map, Ring Signature, VANET security Issues.

Recommended Books

1. Kaufman, C., Perlman, R., Speciner, M. (2002). *Network Security (Latest ed.).* Pub. Prentice Hall.
2. Stallings, W. (2017). *Network Security Essentials: Applications and Standards (6th Ed.)*. Pearson.
3. Maiwald, E. (2007). *Fundamentals of Network Security (Latest ed.).* The McGraw-Hill Companies.

Course Code	Course Title	Credit Hours
CS6809	Introduction to Bioinformatics	3(3+0)

Specializations: General Track, Database Systems, Software Engineering

Prerequisites: Nil

Course Description: This course introduces the emerging area of Bioinformatics. This is a cross disciplinary course which highlights the main computational processes related to Biology.

Aims and Objectives: When students complete this course, they will be able to:

- Receive an introduction and historical perspective to the field of bioinformatics
- Learn the key methods and tools used in bioinformatics
- Build a solid foundation and acquire the vocabulary in bioinformatics for further research

Course Contents: Origin of the Field , Advances in Biology and Computers , Brief Overview of Key Biological Concepts Related to DNA, RNA, Nucleotides, Amino Acids, Proteins, Protein Interaction, Databases and Web Resources, How to Write Algorithms, Calculate Complexities, Nucleotide Analysis Principals and Tools , Sequence Similarity, Dot Matrix, Dynamic Programming for Local , Global Pair Wise Alignment Using Smith-Waterman and Needle-Wunsch Algorithms, GAP Penalties Including Affine GAP Penalty, Scoring and Substitution Matrices (PAM & BLOSUM), Multiple Sequence Alignment, BLAST and FASTA, Dynamic Programming Algorithms, Statistical Models, Artificial Intelligence Algorithms, Protein Analysis Including Protein Structure Prediction from a Sequence. , Phylogenetics, Mutations, Evolution and Protein Families, Clustering, Predictions Using Distance Methods (such as UPGMA etc.).

Recommended Books

1. Attwood, T. K., & Parry-Smith, D. J. *Introduction to Bioinformatics (Latest ed.)*. Pearson Education
2. Lesk, A. (2013). *Introduction to bioinformatics (Latest ed.)*. Oxford University Press.
3. Benson, G., & Page, R. *Algorithms in Bioinformatics (Latest ed.).* Springer.
4. Bockenhauer, H., & Bongartz, D. *Algorithmic Aspects of Bioinformatics (Latest ed.).* Springer.

Course Code	Course Title	Credit Hours
CS6810	Differential Equations	3(3+0)

Specializations: General Track

Prerequisites: Calculus and Analytic Geometry

Course Description: This is a first course in differential equations. The focus is on the geometric interpretation and solution of ordinary differential equations and their application in mathematical modeling in various fields.

Aims and Objectives: The course will enable students to:

- Interpret and solve differential equations of the first order and think of their use in modelling and problem-solving in computer science.

Course Contents: Ordinary Differential Equations of the First Order: Geometrical Considerations, Isoclines, Separable Equations, Equations Reducible to Separable Form, Exact Differential Equations, Integrating Factors, Linear First-Order Differential Equations, variation of Parameters. Ordinary Linear Differential Equations; Homogeneous Linear Equations of the Second Order, Homogeneous Second-Order Equations with Constant Coefficients, General Solution, Real Roots, Complex Roots, Double Root of the Characteristic Equation, Differential Operators, Cauchy Equation, Homogeneous Linear Equations of Arbitrary Order, Homogeneous Linear Equations of Arbitrary Order with Constant Coefficients, Non-homogeneous Linear Equations, Modeling of Electrical Circuits, Systems of Differential Equations, Series Solutions of Differential Equations, Partial Differential Equations: Method of Separation of variables, wave, Heat & Laplace equations and their solutions by Fourier series method.

Recommended Books

1. Micheal, G. (1996). *Advanced Engineering Mathematics (Latest ed.)*. Prentice Hall Publishers.
2. Erwin, K., Herbert, K., & Edward, N. J. (2015). *Advanced engineering mathematics (Latest ed.)*.
3. Zill,. Prindle., Weber., & Schmidt. (1996). *A First Course in Differential Equation (Latest ed.)*. Brooks/Cole Publishing.
4. Zill, D. G. (2016). *Differential equations with boundary-value problems (Latest ed.)*. Cengage Learning.

5. Edwards, C. H., & Penney, D. E. (1989). *Elementary differential equations with applications (Latest ed.)*. Prentice Hall.

Course Code	Course Title	Credit Hours
CS6821	Information Retrieval and Web Search	3(3+0)

Specializations: Web Engineering, Database Systems, Software Engineering, General Track

Prerequisites: Linear Algebra, Probability and Statistics, Advanced Programming, Web Technologies

Course Description: The plethora of information and content available on the public Internet wrought forth a boom in the early 2000s in the area of web search engines. Companies such as Alta Vista, Excite, and Yahoo were the players, and the game had ambitious objectives for all the unknown web pages that existed in cyberspace: (1) locate them in some fashion (through links, through guessing, etc.); (2) obtain the content from those pages; and (3) make that content available to users who enter in a few search terms into an input box on a web page. This is an introductory course for students covering the practices, issues, and theoretical foundations of organizing and analyzing information and information content for the purpose of providing intellectual access to textual and non-textual information resources. This course will introduce students to the principles of information retrieval and search engines systems. It will cover algorithms, design, and implementation of modern information retrieval systems. Topics include: retrieval system design and implementation, text analysis techniques, retrieval models (e.g., Boolean, vector space, probabilistic, and learning-based methods), search evaluation, retrieval feedback, search log mining, and applications in web information management.

Aims and Objectives: When students complete this course, they will be able to:

- Understand the basics and core concepts of information retrieval especially web search engines.
- give an account of the structure of a web search engine.
- Learn to process, index, retrieve, and analyze textual data.

- Learn to evaluate information retrieval systems.
- Learn about web search, crawling and link analysis.
- Build working systems that help users find useful information on the Web - Learn about the state of the art in information retrieval research.

Course Contents: Goals and history of IR, Impact of the web on IR, Boolean and Vector-Space retrieval models, Ranked Retrieval, Text-Similarity Metrics, TF-IDF (Term Frequency/Inverse Document Frequency) Weighting, Cosine Similarity, Tokenizing, Stop-Word Removal, and Stemming, Inverted Indices, Performance Metrics(Recall, Precision, and F-Measure), Relevance Feedback; Query Expansion; Query Languages, Word Statistics, Zipf's Law, Porter Stemmer, Morphology, Index Term Selection, Using thesauri, Metadata and Markup Languages (SGML, HTML, XML), Search Engine Architecture, Spidering, Crawlers and Crawling Strategies, Meta-crawlers, Directed Spidering, Link Analysis (Hubs and Authorities, Google PageRank), Shopping Agents, Content Detection and Analysis, Categorization Algorithms, Nearest neighbor, Naive Bayes, Applications to Information Filtering and Organization, Using Naive Bayes Text Classification for Ad-hoc Retrieval, Improved Smoothing for Document Retrieval, Clustering Algorithms, Agglomerative Clustering, k-means, Expectation Maximization (EM), Ranking, Indexing, Applications to Web Search and Information Organization, Introduction to Nutch, Introduction to Tika, Introduction to Lucene.

Recommended Books

1. Büttcher, S., Clarke, C. L., & Cormack, G. V. (2016). *Information retrieval: Implementing and evaluating search engines (Latest ed.)*. MIT Press.
2. Manning, C. D., Raghavan, P., & Schütze, H. (2008). *Introduction to information retrieval (Latest ed.)*. Cambridge: Cambridge university press.
3. Ceri, S., Bozzon, A., Brambilla, M., Della Valle, E., Fraternali, P., & Quarteroni, S. (2013). *Web information retrieval (Latest ed.)*. Springer Science & Business Media.
4. Baeza-Yates, R., & Ribeiro-Neto, B. (2011). *Modern information retrieval (2nd Ed.)*. Addison-Wesley.

Course Code	Course Title	Credit Hours
CS6822	Service Oriented Architecture	3(3+0)

Specializations: Web Engineering, Software Engineering, General Track

Prerequisites: Web Technologies, Advanced Programming

Course Description: In the past, organizations have adopted computer applications to improve and automate their business processes. These applications have not been implemented according to a strategic plan or based on a common integrated IT infrastructure. Instead, it was based on the needs of each individual department of the company and always according to current technologies. Thus, most organizations have developed information infrastructures consisting of a set of autonomous and in many cases heterogeneous systems. As a result, the need for automated and integrated business processes has increased over the years but organizations were unable to build an integrated IT infrastructure as heterogeneous applications have had several connection problems. In recent years, Service Oriented Architectures (SOA) and technologies are widely used to help organizations overcome these problems. This course focuses on service-oriented architectural model and the service-orientation design paradigm. It will describe Service Oriented Architecture (SOA) concepts and principles, as well as quality considerations for developing modern software systems from a technical and organizational perspective. Specifically, the course will cover principles of SOA design and SOA design patterns. Furthermore, this course covers a wide-range of technologies for gaining the skills to design, build, and maintain a Service-Oriented Architecture (SOA).

Aims and Objectives: When students complete this course, they will be able to:

- Understand the main concepts and principles of SOA.
- Understanding of the strengths and weaknesses of SOA.
- Understand SOA challenges mainly regarding security, governance, testing, and maintenance.
- Implement and deploy simple web services using a suitable development platform.

Course Contents: Definition and Common Understanding of SOA, Relationship Between SOA and Web Services, Advantages and Risks of SOA, SOA History and Present, Compare SOA with other Architectures, SOA Applications' Lifecycle, Techniques and SOA Development Methodologies, Comparison and Evaluation of SOA Development Methodologies and Best Practices, Types and Function of Web Services, XML, SOAP, REST, WSDL, UDDI, Enterprise Service Bus (ESB), Process Driven Service (PDS), Overview of Service Oriented Analysis and Design (SOAD),Web Service Programming using Java EE, SOA QoS, SOA Security.

Recommended Books

1. Papazoglou, M. (2008). Web services: principles and *technology (Latest ed.)*. Pearson Education.
2. Erl, T. (2009). *SOA design patterns (Latest ed.)*. The Prentice Hall Service-Oriented Computing Series, Prentice Hall.
3. Weerawarana, S., Curbera, F., Leymann, F., Storey, T., & Ferguson, D. F. (2005). *Web services platform architecture: SOAP, WSDL, WS-policy, WS-addressing, WS-BPEL, WS-reliable messaging and more (Latest ed.)*. Prentice Hall PTR.

Course Code	Course Title	Credit Hours
CS6823	Wearable Technology	3(3+0)

Specializations: Web Engineering, General Track

Prerequisites: Mobile Applications Development

Course Description: This course invites students to examine the wearable technologies that are just starting to become part of our everyday lives. Wearables live on our wrists, attached to our eyeglasses, and embedded in our clothes. Wearable technologies field has been experiencing explosive growth with exciting applications in the fields of medicine, sports, fitness, entertainment, as well as new ways for people to interact, communicate, and experience the environment around them. This course gives an overview of ecosystem and current and future prospects of the wearable technologies, study the technology building blocks that empower wearable computing, master mobile programming skills for wearable devices, and turn creative ideas into innovative wearable products. It also introduces the basic open-source hardware and software platforms to provide elementary but insightful techniques for students to start their own projects. Through the introduction of wearable technology, the course aims at inspiring students' creativities and interests in generating innovative designs for future wearables systems. This is a agile course which will focus on new and emerging technologies. The individual topics may change if there is a significant new technology available at the start of the course.

Aims and Objectives: When students complete this course, they will be able to:

- Understanding and insight knowledge of wearable technologies and a wide range of cutting-edge projects in the related fields.
- Learn different aspects and issues of using wearable gadgets for solving different daily life problems.
- Learn the basics and differences of a wide range of wearable APIs and SDKs.
- Designing and creating of their projects in the field of wearable technology.
- Implement and deploy simple Android applications for suitable wearable devices.

Course Contents: Ecosystem of Wearable Computing, Background and History of Wearables, Attributes and Taxonomy of Wearables, Impact of Wearable Technology, Wearable Technology in Ethics, Limitations of Wearable Technology, Variety of Wearable Devices and Applications at Various Body Parts, Sensor Technologies for Wearables and Applications, Applications of Wearable Systems in Dfferent Domains, Challenges and Opportunities in Wearable Technology, Security and Privacy Risks, Embedded Software Programming, Bluetooth Low Energy (BLE), Software Platforms for Wearables, Android Wear Programming, Advance Techniques for Wear Programming, Cloud Storage for Wearable Data, Students Group Project.

Recommended Books

1. Sazonov, E., & Neuman, M. R. (Eds.). (2014). *Wearable Sensors: Fundamentals, implementation and applications (Latest ed.)*. Elsevier.
2. Heydon, R. (2013). *Bluetooth low energy (Latest ed.)*. Prentice Hall.
3. Annuzzi Jr, J., Darcey, L., & Conder, S. (2014). *Advanced Android Application Development (4th Ed.)*. Pearson Education.
4. Ruiz, D. C., & Goransson, A. (2015). *Professional Android Wearables (Latest ed.)*. John Wiley & Sons.
5. Ryan, S. E. (2014). *Garments of paradise: wearable discourse in the digital age (Latest ed.)*. MIT Press.

Course Code	Course Title	Credit Hours
CS6831	Emerging Computer Networks	3(3+0)

Specializations: Computer Networks, General Track

Prerequisites: Wireless and Mobile Networks

Course Description: This course focuses on the advance topics in the area of computer networks. The course consists of both a reading/lecture/discussion component and a project component. The focus will be on the existing technologies in addition to why some of them are not sufficient due to lack of support in technology or changes in fundamental assumptions.

Aims and Objectives: When students complete this course, they will be able to:

- Comparison of current network technologies with futuristic technologies.
- Understanding the requirements of future in relation with connectivity and communication.
- Effective utilization of network resources in comparison of physical and virtual environment.
- Understanding High speed data networks such as 5G and millimetre wave.

Course Contents: Data Center Network Topologies, Networking Issues for Big Data, Wireless Personal Area Networks (LOWPAN), The Challenges and Architecture of Software Defined Networking (SDN), Enabling Technologies of 5G Network and Beyond such as Millimeter Wave Communication, Machine Type Communication (MTC), Massive MIMO, Wireless Full Duplex Communication; Device to Device Communication in LTE-A with and without BS support, Massive and Ultra-Reliable Machine Type Communication and its Support in Cellular Networks, Data Offloading, Aggregation and Caching in Cellular Networks, Advantages and Challenges; SDN for 5G and Network Function Virtualizing (NFV), Radio Frequency Identifier (RFID), Body Area Networks (BAN), Energy Harvesting and Energy efficiency in HetNets, Delay Tolerant Networks, Protocol Suit, Issues and Comparison with TCP/IP Suit, Vehicular Adhoc Networks (VANETs), Performance, Challenges and Comparison with other Emerging Networks, Intelligent Transport System, Application and Architecture.

Recommended Books

1. Rodriguez, J. (2015). *Fundamentals of 5G Mobile Networks (Latest ed.).* John Wiley & Son Ltd..
2. Makaya, C., & Pierre, S. (2011) *Emerging Wireless Networks: Concepts, Techniques and Applications (Latest ed.).* CRC Press.
3. Huq, M. S., & Rodrigue, J. (2017). *Backhauling / Fronthauling for Future Wireless Systems (Latest ed.).* John Wiley & Son Ltd.

Bibliography

1. Lakatos, L., Seidl, L., & Telek, M. (2012). *Introduction to Queuing Systems with Telecommunication Applications (Latest ed.).* Springer Science & Business Media.

Course Code	Course Title	Credit Hours
CS6832	Network Administration	3(3+0)

Specializations: Computer Networks, General Track

Prerequisite: Computer Networks

Course Description: The focus of this course is to manage the local area network under different network operating systems.

Aims and Objectives: When students complete this course, they will be able to:

- Creating and designing a computer network.
- Managing computer networks under different network operating systems.
- Troubleshooting for any network related issues.

Course Contents: Review of TCP/IP, Overview of Network Services-Windows, Network Planning, Implementation, Deployment, and Management under Network Operating System, Implementation and Management of Network Services, Overview, Installation and Configuration of MRTG, Installation and Maintaining NEO, Overview, Installation and Examples of NETFLOWS, Using and Maintaining OAK, Overview and use of tcpdump,

Linux/Solaris Planning for Network Services. Basic of TCP/IP Configuration (Windows/Linux), DNS Services (Windows/Linux), Review and Labs, DHCP Services in Windows and Linux, Directory Services-Windows Active Directory, Windows Domain Service, Print/File Server, Network File System, Troubleshooting TCP/IP, Routing Services-Linux/Solaris, Switch Configuration, Virtualization, Firewall and Policies Implementations, IPv6 Implementation and Deployment, SNMP Implementation and Management.

Recommended Books

1. Wahl, C., Pantol, S. (2014). *Networking for VMware Administrators (Latest ed.).* Pearson Education.
2. Limoncelli, T. A., Hogan, C. J., Chalup, S. R. (2016). *The Practice of System and Network Administration (Latest ed.).* Pearson Education.
3. Murphy, N. R., Malone, D. (2005). *IPv6 Network Administration (Latest ed.).* O'Reilly Media.
4. Hunt, C. (2002). *TCP/IP Network Administration (3rd Ed.).* O'Reilly Media.
5. Kretchmar, J. M. (2004). *Open Source Network Administration (Latest ed.).* Prentice Hall.

Course Code	Course Title	Credit Hours
CS6841	Big Data Concepts	3(3+0)

Specializations: Database Systems, Software Engineering, General Track

Prerequisites: Database Systems

Course Description: This introductory course in big data helps you understand concepts and issues related to big data systems. Big data consists of very large or complex data sets that cannot adequately be stored, processed or analyzed through traditional, relational database technologies. It also includes a wide variety of data types and high-velocity data streams. You gain an understanding of the concepts and issues related to designing and using big data systems.

Aims and Objectives: Students successfully completing this course should be able to understand:

- What Big Data is?
- The components necessary to build a Big Data environment.
- Map-Reduce Programming Paradigm.
- The Hadoop ecosystem.

Course Contents: Introduction to the Big Data and its problems, Big data and its impacts, Current challenges, trends, and applications, Management of unstructured and structured data, Distributed computing and distributed infrastructure. Introduction to large scale file systems, operations and parallel processing algorithms. Technologies for Big Data management, Big Data technology and tools, Cloud and Big Data, Operational Databases (relational and non-relational databases, key value pair database, document database, graph database) special consideration made to the Map-Reduce paradigm and the Hadoop ecosystem.

Recommended Books

1. Mayer-Schönberger, V., & Cukier, K. (2013). *Big data: A revolution that will transform how we live, work, and think (Latest ed.)*. Houghton Mifflin Harcourt.
2. Karau, H., Konwinski, A., Wendell, P., & Zaharia, M. (2015). *Learning spark: lightning-fast big data analysis (Latest ed.)*. O'Reilly Media, Inc.
3. Smolan, R. (2013). *The human face of big data. Against All Odds Productions (Latest ed.)*.

Course Code	Course Title	Credit Hours
CS6842	Database Administration	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Database Systems

Course Description: Establish expertise in fundamental concepts of Database Administration. This course concentrates on the principles, rules, techniques, tools used in a Database administration.

Aims and Objectives: Students successfully completing this course should be able to:

- Understand SQL queries of a database system.
- Have in-depth knowledge of RDBMS and Database architecture.
- Strong concept of managing memory areas, performance and tuning of database.
- Apply backup and recovery techniques.

Course Contents: Database, Data, and System Administration, DBA Tasks, The Types of DBAs, Creating the Database Environment, Defining the Organization's DBMS Strategy, Choosing a DBMS, Architecture, Clustering, Proliferation and Issues, Data Modeling and Normalization, Data Modeling Concepts, Normalization Concepts, Database Design, From Logical Model to Physical Database, Database Performance Design, De-normalization, Application Design, Database Application Development and SQL, Types of SQL, Defining Transactions, Locking, Design Reviews and its Types, Design Review Output, Database Change Management, Change Management Requirements, Types of Changes and its Impact Database Structures, Data Availability, Cost of Downtime, Performance Management, Reactive and Proactive measurements, Types of Performance Tuning, System Performance, DBMS Installation and Configuration Issues, Logs Monitoring, Database Performance, Techniques for Optimizing Databases, Indexing and Free Space, Application Performance, Relational Optimization, Additional Optimization Considerations, Data Integrity, Backups And Recovery

Recommended Books

1. LaRock, T. (2010). *DBA Survivor (Latest ed.)*. Springer.
2. Mullins, C. (2002). *Database administration: the complete guide to practices and procedures (Latest ed.)*. Addison-Wesley Professional.
3. Fernandez, I. (2009). *Beginning Oracle Database 11g Administration: From Novice to Professional (Latest ed.)*. Dreamtech Press.

Course Code	Course Title	Credit Hours
CS6843	ETL (Extract, Transform, Load) Programming	3(3+0)

Specializations: Database Systems, General Track

Prerequisites: Nil

Course Description: This course focuses on ETL solutions. The designed audience should have adequate SQL programming skills and basic data warehouse concept. This course covers the core components of ETL architecture.

Aims and Objectives: Upon completion of this course, the audience should be able to:

- Understand Power Centre core components and how data flow through each component.

Course Contents: Basic ETL and data warehouse concept, connectivity from/to different types of data source/target, mapping specification and mapping development, creating and running workflow and session, using repository to copy/deploy/maintain ETL codes, debugging mapping, checking log files and finding performance bottleneck, illustrating the best practices of designing ETL solution, Architecture, Administrator's Components of an ETL tool, working with source/target, running and monitoring job execution, Transformations: Source Qualifier, Expression, Filter, Lookup, Router, Update Strategy, Sequence Generator, Normalizer, Other Transformations, Debugging A Mapping: Error Logging, Check Log Files, Debug Step by Step, Reusing/Sharing Designer Objects: Reusable Transformation, Mapplet, Advanced Designer Topic: Slowly-Changing Dimension, Dynamic Lookup, Mapping Parameter and Variable, Foreign-Key Based Loading, Understand Mapping Specification, Advanced Workflow Manager Topic: Parameter File, Worklet, Control Task, Command Task, E-mail Task, Event Raise/Wait Task, Code Promotion

Recommended Books

1. Kimball, R., & Caserta, J. (2011). *The Data Warehouse? ETL Toolkit: Practical Techniques for Extracting, Cleaning, Conforming, and Delivering Data (Latest ed.)*. John Wiley & Sons.

Course Code	Course Title	Credit Hours
CS6851	Software Project Management	3(3+0)

Specializations: Software Engineering, Database Systems, General Track

Prerequisites: Software Engineering

Course Description: This course describes the key aspects of a software project and project management. The focus is placed on project management knowledge areas and associated processes as described by Project Management Institute(PMI).

Aims and Objectives: After completing the course, students should be able to:

- Identify organizational influences and project life cycle.
- Work with project management processes.
- Initiate and plan a project.
- Plan for project time management.
- Plan project budget, quality, and communications.
- Plan for risk, procurements, and stakeholder management.
- Execute a project and manage project work, scope, schedules, and cost.
- Control a project. and close a project

Course Contents: Software Crisis and Software Engineering, Classic Mistakes, Overview of Project Management, Project proposal and Request for Proposal (RFP) overview. PMI Process Groups, Software project Phases, Project charter, Statement of Work (SOW), Planning Phase: matching lifecycles to projects, Project plans, Work Breakdown Structures (WBS), Estimation of effort and cost (Expert Judgment, Function Points and Use Case point methods), Scheduling: Project network diagram fundamentals, Critical Path Method(CPM), PERT charts, Gantt charts, Using MS-Project, Assigning Resources, Resource leveling, Team models, Managing conflict and motivating, Project Monitoring and Control: Status reporting,

Project metrics, Earned Value Management, Communications Techniques, Risk management and Change control, Documentation, Cutover/Migration, Post Project Reviews, Closing. High level comparison between PMI, CMMI and PRINCE2.

Recommended Books

1. Duncan, W.R. (2015). *A guide to the project management body of knowledge (5th Ed.)*. PMBOK® guide, Beijing: Dianzigongyechubanshe.

Bibliography

1. Hughes, B., & Cotterell, M. (2009). *Software project management (1st Ed.)*. London: McGraw-Hill.

Course Code	Course Title	Credit Hours
CS6852	Software Testing	3(3+0)

Specializations: Software Engineering, General Track

Prerequisites: Advanced Programming, Software Engineering

Course Description: This course presents theory and practice of software testing. It covers structural testing including such topics as syntax testing, mutation testing, tools for software testing, testing specifications, black-box and white-box testing, code inspections, metrics, usability testing, testing documentation, website testing, security testing, beta testing, quality assurance, and software safety.

Aims and Objectives: After completing the course, students should be able to:

- Understand the concepts and theory related to software testing.

- Understand different testing techniques used in designing test plans, developing test suites, and evaluating test suite coverage
- Understand the relationship between black-box and white-box testing and know how to apply as appropriate.
- Learn to use automated testing tools in order to measure code coverage.
- Understand how software developers can integrate a testing framework into code development in order to incrementally develop and test code.

Course Contents: Introduction to software quality assurance, The Quality Challenge, Quality Control v/s Quality Assurance, Quality Assurance in Software Projects (Phases), Quality Assurance and Standards, Verification and Validation Planning, Software Quality Assurance (SQA) Plans, Software testing realities, Code coverage, Specification based test construction techniques, Black box, White-box and grey-box testing, Control flow oriented test construction techniques, Data flow oriented test construction techniques, Clean-room approach to quality assurance, Product Quality and Process Quality, Walkthroughs and code inspections, Web testing, Integrating testing into software development process, Test automation.

Recommended Books

1. Crispin, L., & Gregory, J. (2014). *Agile testing a practical guide for testers and agile teams (1st Ed.)*. Upper Saddle River: Addison-Wesley.
2. Homès, B. (2012). *Fundamentals of software testing (Latest ed.)*. Hoboken, NJ: ISTE / Wiley.

Bibliography:

1. Godbole, N. (2007). *Software quality assurance (1st Ed.)*. Oxford, U.K.: Alpha Science International Ltd.

Course Code	Course Title	Credit Hours
CS6853	Open Source Development	3(3+0)

Specializations: Software Engineering, Web Engineering, General Track

Prerequisites: Software Engineering, Object Oriented Analysis and Design, Advance Programming

Course Description: The course Introduces concepts, principles and applications of open source software. Discusses open source software development process. Cover economy, business, and societal and intellectual property aspects of open source software.

Aims and Objectives: Upon successful completion of the course the student will be able to:

- Understand concepts, strategies, and methodologies related to open source software development.
- Understand the business, economy, societal and intellectual property issues of open source software.
- Be familiar with open source software products and development tools currently available on the market.

Course Contents: The origins of the Open Source approach, The Open Source Definition, licenses (MPL, GPL, LGPL, etc.) and their effects; Contrasting and comparing open source vs. traditional development methodologies, a comparison of the Free Software Foundation and the Open Source community; a comparison of Open Source software and proprietary software; benefits, costs, risks; current issues and challenges , Open Source project management tools, Source code management and revision control, the Concurrent Versions System, problem reporting, clearing houses, groupware; major Open Source applications/projects: e.g. office suites, graphical products; major Open Source commercial organizations and their contributions; software development using Open Source methodologies and tools.

Recommended Books

1. Tomlinson, M. (2016). *How to Become an Expert Software Engineer (and Get Any Job You Want): A Programmer's Guide to the Secret Art of Free and Open Source Software Development (Latest ed.)*. Create Space Independent Publishing Platform.

Bibliography

1. Coleman, E. (2013). *Coding freedom (1st Ed..)*. Princeton: Princeton University Press.
2. Raymond, E.S. (2001). *The Cathedral & the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary (Latest ed.)*. O'Reilly Media.

Course Code	Course Title	Credit Hours
CS6861	Machine Learning	3(3+0)

Specializations: Pattern Recognition, Database Systems, General Track

Prerequisites: Statistics and Probability, Linear Algebra, Advanced Programming, Data Structures and Algorithms

Course Description: The aim of the course is to give students a basic understanding of the theory of machine learning, and its techniques and algorithms. Further, the objective of the course is to prepare students to learn machine learning at an advanced level.

Aims and Objectives: After completing this course:

- Students will be able to understand the theory of machine learning at a preliminary level and learn and apply some basic machine learning techniques.

Course Contents: Linear regression with one variable, linear algebra review, linear regression with multiple variables, logistic regression, regularization, neural networks, neural network learning, deep learning, fast nearest neighbor method, machine learning system design, support vector machines, un-supervised learning, dimensionality reduction,

anamoly detection, recommender system, large-scale machine learning. Some advanced topics including Markov decision processes, dynamic programming, and deep reinforcement learning.

Recommended Books

1. Bishop, C. (2011). *Pattern recognition and machine learning (Latest ed.)*. Springer.
2. Harrington, P. (2012). *Machine learning in action (5th Ed.)*. Greenwich, CT: Manning.
3. Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2012). *Foundations of machine learning (Latest ed.)*. MIT press.
4. Richert, W. (2013). *Building machine learning systems with python (Latest ed.)*. Packt Publishing Ltd.

BS (CS)

Old Course Outline

University of Peshawar

Department of Computer Science

UNDERGRADUATE CURRICULUM

BCS

A Student majoring in Bachelor in Computer Science (BCS) must complete minimum of 132 Credit Hours courses. The courses list is as follows:

Semester I		
Course #	Title	Cred.Hrs.
BCS111	Fundamentals of Computers.	3
BCS112	Mathematics-I	3
BCS113	Probability and Statistics	3
BCS114	Functional English	3
BCS115	Programming Concepts	4
		16
Semester II		

Course #	Title	Cred.Hrs.
BCS121	Programming Languages-I	4
BCS122	Mathematics-II	3
BCS123	Physics	3
BCS124	Discrete Mathematics	4
BCS125	Pakistan Studies/Islamic studies	3
		17

Semester III

Course #	Title	Cred.Hrs.
BCS231	Digital Logic Design	3
BCS232	Database-I	4
BCS233	Data Structures	3
BCS234	Business Communication	3
BCS235	Electronics	3
		16

Semester IV		
Course #	Title	Cred.Hrs.
BCS241	Database-II	3
BCS242	Programming Languages-II	4
BCS243	Operating Systems	4
BCS244	Computer Organization and Assembly Language Programming	3
BCS245	Data Communications and Networking	4
		18

Semester V		
Course #	Title	Cred.Hrs.
BCS 351	Internet Programming	3
BCS352	Artificial Intelligence	3
BCS353	Analysis of Algorithms	3
BCS354	Programming Languages-III	4
BCS355	Software Engineering-I	3

BCS356	Network Strategies	3
		19
SemesterVI		
Course #	Title	Cred.Hrs.
BCS361	Computer Architecture	3
BCS362	Numerical Analysis	3
BCS363	Automata Theory	3
BCS364	Computer Graphics	4
BCS365	Software Engineering-II	3
		16
SemesterVII		
Course #	Title	Cred Hrs
Compulsory		
BCS471	Compiler Construction	3
BCS472	Wireless and Mobile Communications	3
BCS473	Software Project-I	3
Elective ***(any two)***		
BCS474	Digital Signal Processing	3

BCS475	E-Commerce Applications & Technologies	3
BCS476	Expert Systems	3
BCS477	Data Mining and Data Warehousing	3
BCS478	Management Information System	3
BCS479	Distributed Computing	3
Total Semester Cred Hrs		*15*
SemesterVIII		
Course #	Title	Cred Hrs
Compulsory		
BCS481	Software Project Management	**3**
BCS482	**Natural Language Processing**	3
BCS483	**Software Project-II**	3
Elective ***(any two)***		
BCS484	Digital Image Processing	3
BCS485	Network Security	3
BCS486	Modeling and Simulation	3
BCS487	Database Administration	3
BCS488	Telecommunication systems	3
BCS489	Multimedia Technologies	3
Total Semester Cred Hrs		**15**

Note:

1. Only those elective courses will be offered whose teaching staff will be available.
2. Students can select any of the two offered elective courses of their choice.
3. Only those elective courses will be offered whose students' strength will be 10 or above.

(The courses and semester plan can be modified subject to the decision of board of studies.)

Computer Science Courses

Compulsory subjects		
S.No.	**Title**	**T/Credits**
1.	Fundamentals of Computers	3
2.	Programming Concepts	4
3.	Programming Languages-I	4

4.	Digital Logic Design	3
5.	Database-I	4
6.	Data Structures	3
7.	Database-1I	3
8.	Programming Languages-II	4
9.	Operating Systems	4
10.	Computer Organization and Assembly language Programming	3
11.	Data Communications and Networking	4
12.	Internet Programming	3
13.	Artificial Intelligence	3
14.	Analysis of Algorithms	3
15.	Programming Languages-III	4
16.	Software Engineering –I	3
17.	Network Strategies	3
18.	Computer Architecture	3
19.	Automata Theory	3
20.	Computer Graphics	4
21.	Software Engineering –II	3
22.	Compiler construction	3
23.	Wireless and Mobile communication	3
24.	Software Project Management	3
25.	Natural Language Processing	3
26.	Software Project-I	3
27.	SoftwareProject-II	3

	Cred Hrs of Compulsory Courses	**89**
Elective subjects (6 credit hours in semester 7 and 6 credit hours in semester 8)		
	Digital Signal Processing	
	E-Commerce Applications & Technologies	
	Expert Systems	
	Data Mining and Data Warehousing	
	Management Information System	
	Distributed Computing	
	Digital Image Processing	
	Network Security	
	Modeling and Simulation	
	Database Administration	
	Telecommunication System	
	Multimedia Technologies	
	Cred Hrs of Elective Courses (four to be chosen)	**12**
	Total Cred. Hrs of Computer Science courses	**101**

Mathematics Courses

S.NO.	Title	T/Credits
1.	Mathematics-I	3
2.	Discrete Mathematics	4
3.	Mathematics-II	3
4.	Statistics & Probability	3
5.	Numerical Analysis	3
	Total Cred. Hrs of Mathematics courses	**16**

Natural Sciences Courses

S.NO.	Title	T/Credits
1.	Physics	3
2.	Electronics	3
	Total Cred. Hrs of Natural Sciences courses	**6**

Social Sciences Courses

S.NO.	Title	T/Credits
1.	Functional English	3
2.	Pakistan Study/ Islamic Studies	3
3.	Business Communication	3
	Total Cred. Hrs of Social Sciences courses	**9**

Department of Computer Science

University of Peshawar

UNDERGTRADUATE CURRICULUM

BCS

Code: BCS111 Credit Hours: 3

Fundamentals of Computers

Basic of Computer

a) Introduction and history of Computers.
b) Types of Computer
c) Computer Organization

Computer Software

a) Software Introduction
b) Types of Software
c) PC Platform.
d) Computer Virus.

Data Processing and Storage

a) Data Processing Techniques
b) Data Storage (Bit, Byte, RAM, ROM, cache Memory, Secondary Storage (FDD, HDD, Tape, CD).

The Processor

a) Bus, Port
b) Computer Motherboard.
    1. Microprocessor
    2. Math Co-processor
    3. Memory Chip
    4. Support Chips
    5. Built-in programs
    6. Expansion Slots

Input and Output Devices.

a) Input Devices
    1. Keyboard and its types
    2. Point and Draw devices
    3. Scanner, Digital Camera, Speech recognition system and multimedia
b) Output Devices
    1. Monitor(Graphic Adopter, Size, Resolution and Types of Monitors)
    2. Printers and Types (Dot matrix, inkjet and laser)
    3. Plotters (Raster and Pen)
    4. Presentation Graphics and special function terminals (ATMs POSs)

Windows

a) Windows Introduction
b) Finding Files, Installing Printers
c) The Desktop and types of windows(application, document, dialog)
d) Elements of an application window
e) Understanding folders, copying, detecting and moving files

Word Processing (MS Word)

a) Basic concepts and features

b) Creating, saving, editing, formatting and printing documents
c) Working with Tables

Electronic Spreadsheet (MS Excel)

a) Basic concepts and features
b) Creating, saving Excel sheet, editing the sheet
c) Managing formula, formatting the sheet and printing the sheet
d) Working on workbook

Basics of Internet usage

a) Introduction
b) World Wide Web and Web sites
c) Introduction to Internet based services and use of E-mail.

Books:

1. *Sawyer, William, Hutchinson, Using Information Technology, 2nd Edition, McGraw Hill, 2000.*
2. *J. Glenn Brookshear,Computer Science: An Overview, 8th Edition, Addison-Wesley, 2005.*
3. *Timothy J. O'Leary, Linda I. O'Leary, Computing Essentials, 15th Edition, McGraw-Hill's Primis Custom Publishing,2004*

Code: BCS112 Credit Hours: 3

Mathematics-1(Calculus-1)

Real and Complex Numbers

a) Real Numbers
b) Complex numbers

Functions, Limit and Continuity of a function.

a) Functions
b) Graphs
c) Sequences
d) Limit and Continuity of a function of one variable

Differentiation-1

a) Differentiation
b) Product and Quotient Rules
c) Tangent
d) Normal

Differentiation-II

a) Chain Rule
b) Implicit differentiation

Application of Differentiation-1

a) Roll's and Mean Value Theorem
b) Taylor's Theorem
c) Maclaurin's Theorem

Application of Differentiation-II

a) Newton's and Picard's method and its application
b) Maxima
c) Minima

Indeterminate forms

a) L'Hospital's Rule
b) Application of L'Hospital's Rule

Integration

a) Basic Integration
b) Integration by identities
c) Integration by substitutions
d) Integration of trigonometric functions
e) Integration by parts

Application of Integration

a) Area and Volume by integration

b) Differential Equations (Separable variables techniques)

Books:

1. *Anton Howard, Calculus, John Wiley & Sons Inc, 1999.*
2. *George B.Thomas, Ross L. Finney, Maurice D. Weir, Frank R. Giordano, CALCULUS, 10th Edition, Addison Wesley Publishing Company, 2002.*

Code: BCS113 Credit Hours: 3

Probability and Statistics

Introduction

a) Meaning of statistics
b) Importance of statistics in various fields
c) Population and Sample
d) Variables
e) Statistical data

Statistical Measures of Data

a) Measures of Central Tendency, Mean, Median, Mode and quartiles
b) Measures of Variation: Range, Standard Deviation, Variance and Coefficient of Variation.

Sets and Probability

a) The concept of a Set
b) Set Operations and Algebra of Sets
c) Permutations and Combinations
d) The Concept of Probability
e) Theorems of Probability
f) Conditional Probability

Random Variables and Probability Distribution

a) Concepts of a Random Variable
b) Discrete Probability Distributions

c) Continuous Probability Distributions
d) Joint Distribution of two random variables
e) Mathematical Expectations

Special Probability Distributions

a) Binomial Distribution
b) Poisson Distribution
c) Hypergometric Distribution
d) Uniform Distribution
e) Normal distribution

Sampling Theory

a) Sampling Distribution
b) Sampling Distribution of the Mean
c) Sampling Distribution of the differences of means
d) Sampling Distribution of Proportions
e) Sampling Distribution of the Difference of Proportions

Statistical Inference

a) Point estimation
b) Properties of a good estimator
c) Confidence Intervals
d) Statistical Hypothesis
e) Testing a Statistical Hypotheses Tests Concerning Means
f) Tests Concerning Means
g) Tests Concerning Difference between two Means
h) Goodness of Fit Test and Test for Independence

Simple Linear Regression and Correlation

a) Simple Linear Regression
b) Least Squares estimation of the Regression Parameters
c) Inference concerning the Regression Coefficients
d) Linear Correlation
e) The coefficient of correlation

f) Properties of the coefficient of correlation

Books:

1. *Ronald E. Walpole, Introduction to Statistics, Latest edition, Macmillan Publishing Co. Inc. New York, 1999.*
2. *I. Miller and J.E Freund, Probability and Statistics for Engineers, 4th Edition, Prentice Hall, 1990.*

Code: BCS114 Credit Hours:3

Functional English

Function		**Asking and answering questions**
a)	Structure	The Present perfect
b)	Reading	Guessing the meanings of words
c)	Writing	Informal letters: beginning and ending
d)	Listening	Understanding directions

Function		**Seeking Agreement and Confirmation**
a)	Structure	The Present Perfect and simple past tense
b)	Reading	Guessing the meanings of words
c)	Writing	Joining Sentences
d)	Listening	Listening to a narrative account

Function		**Agreeing and Disagreeing**
a)	Structure	Reported Speech
b)	Reading	Predicting

c) Writing Informal letters

d) Listening Giving advice

Function Possibility/Impossibility

a) Structure Conditionals

b) Reading Skimming and Scanning

c) Writing Formal letters

d) Listening Listening to talk/lecture

Function Certainty/Uncertainty: obligations

a) Structure The Passive

b) Reading Function in a text

c) Writing Formal letters

d) Listening Listening to an interview

Function Preferences/Interactions

a) Structure The ing form

b) Reading Reading the main idea and supporting details in text

c) Writing Formal letters

d) Listening Listening to a talk/lecture

Function Permission

a) Structure The Past Perfect and future perfect tense

b) Reading Classification

c) Writing Applying for a job

d)	Listening	Listening to a radio broadcast

Function		**Appreciation, regret and indifference**
a)	Structure	Relative Clauses
b)	Reading	Thermatization
c)	Writing	Note Taking
d)	Listening	to an argument

Function		**Suggesting/Warning**
a)	Structure	Relative Clauses
b)	Reading	Facts and Opinion
c)	Writing	Summarizing
d)	Listening	Listening to a story.

Books:

CA Exams Study Text: Modular Foundation Examination Module-A Paper A1 Functional English, 3rd Edition, Professional Business Publications, Lahore, Pakistan, 2000.

Code: BCS115 Credit Hours: 4

Programming Concepts

Introduction to Computer Program

a) Computer program concepts, High level languages, 4 GL
b) Editor, Compiler, Source Program, Object Program

Computer Program Engineering

a) Introduction, problem solving techniques, qualities of a good program
b) Program life cycle

Computer Program Basics

a) Basic program structure, (Input, Output, process)
b) Constant, Variable, data types, operators, expression, statement

1/O and Debugging

Input/Output statements, debugging procedures, errors logical, syntax

Transfer of control structures

a) Conditional/Conditional
b) Simple decision (if-then-else)
c) Complex decision(case structure/nested decision)

Repetition

For structure, while structure, repeat structure Recursion

Arrays

Arrays (introduction, single, multidimensional

Functions and Subprograms, Recursion

Storage Classes

Memory Management Model

String Handling

Character testing and Data Conversion

Far pointer and VDU (Video Display Unit)

Bit wise operators

Union

Preprocessor. Commands

Files (All access modes,) character I/O on file, line oriented I/O on file, file

Management, Non-Text file I/O

Command Line Arguments (hard coding vs flexible coding)

Calling interrupt

Re-direction Request

Books:

1. *Robert Lafore, C programming Using Turbo C++, SAMS Publishing, 1997.*
2. *Mian Altafullah, C Theory & Practice.*
3. *Deitel & Deitel, C How to Program, 3rd Edition, Prentice Hall, 2000.*

Code: BCS121 Credit hours: 4

Programming Language-I(C++)

Overview of Arrays and Functions

a) Arrays (Fundamentals, Arrays as Class member data, as Objects, Strings)
b) Function (Declaration, Calling, passing arguments, returning values)
c) Function overloading inline functions.

Structures and Unions

Structures (Structure specification & definition, Accessing structure elements)

Enumerated Data Type and Storage Classes

Enumerated data declaration and use, Automatic, External and Static variables, Registers

Introduction to Objects Oriented programming

a) Advantages of Object Oriented approach, Objects
b) Classes, Inheritance, Reusability, creating new data types
c) Polymorphism, overloading.

Dealing with Classes and Objects in C++

a) Specifying and using Classes and Objects, Constructors and Destructors
b) Objects and function argument, Returning objects from functions

Operator overloading, Inheritance, pointer, special functions, and Files & Streams

Operator overloading (Unary operators, Binary operators, Data Conversion, pilfalls)

a) Inheritance

1. Derived and Base Classes, Derived Class Constructors
2. Overriding member functions, class hierarchies, Public & Private Inheritance.
3. Levels of Inheritance, Multiple inheritance.

b) Pointers

1. Address and Pointers, Pointers and Arrays
2. Pointers and Functions, Pointers and Strings, Memory allocation and de allocation

c) Some Special Types of Functions

1. Virtual Functions, friend functions, static functions.

d) Files and Streams

1. Streams, String 1/O, Character 1/O Object 1/O with multiple objects
2. File pointers, Disk 1/O with member functions, error Handing
3. Redirection of input and Output Command Line Arguments, Printer Output.

Books:

Robert Lafore, Turbo C++, 2nd Edition, SAMS Publishing, 1997.

Code: BCS122 Credit Hours: 3

Mathematics-II(Calculus-II)

Vector-I

a) Vectors
b) Vector Analysis

Vector-II

a) Calculus of vectors
b) Application of Vector Calculus

Infinite Series

a) Sequence, Monotonic Sequence, Infinite Series
b) Convergence, integral Tests, Convergence Test, Comparison Test
c) Alternating Series, Conditional Convergence

Functions of Several Variables

a) Functions of several variables
b) Limit and continuity of function of several variables
c) Partial derivatives

Hyperbolic Functions

a) Hyperbolic Functions
b) Calculus of Hyperbolic Functions

Higher Integration

a) Reduction Formula
b) Some more techniques of integration

Application of integration

a) Line integral
b) Multiple integrals
c) Double and triple integrals

First order differential equations

First order differential equations

Second order differential equations

Second order differential equations/

Books:

1. *Antom Howard, Calculus, John Wiley & Sons Inc, 1999.*
2. *George B.Thomas, Ross L. Finney, Maurice D. Weir, Frank R. Giordano, CALCULUS, 10th Edition, Addison Wesley Publishing Company, 2002.*

Code: BCS123 Credit Hours:3

Physics

Electrostatics

a) Coulomb's Law
b) Coulomb's Law and its experimental verification
c) Electric Charge
d) Charge quantized
e) Electric fields
f) Gauss' Law
g) Electric Potential
h) Flux of electric field, Gausses law and its application
i) Electric potential as line integral potentials due to charge distribution, potential and field due to bipole
j) Capacitors and dielectrics
k) Equation of continuity
l) Capacity of a spherical and parallel plate capacitor, polarization of matter
m) Gausses law in dielectrics, electric susceptibility and dielectric constant

n) Energy density of electrostatic field

Electric Current and Magnetic Fields

a) Current and magnetic field, electric current, Ohm's law
b) Equation of continuity
c) Field due to a current interaction of magnetic field with current
d) Magnetic induction vector B. Biot Savart law
e) Field due to a straight and circular current
f) Ampere's law, Ampere's circuital theorem
g) Fields due to a solenoid and a toroid, thermo electrically feedback
h) Pelter and Thomson's effect, total e.m.f in thermocouple
i) Photo Voltaic effect pi electric effect
j) Faraday's law, Faraday's law of electromagnetic induction and its
k) Differential form
l) Self induction, self inductance of a toroidal solenoid, mutual induction
m) Mutual inductance of toroidal solenoid
n) Magnetic fields in matter-I, magnetization vector, the magnetic intensity
o) Vector H
p) Magnetic energy, dia, para and ferro magnetism phlegmatic hysteresis

Maxwell's Equations

a) Maxwell's equations
b) Maxwell's equations, wave equations and its plane, wave solution in free pace
c) Relation between the propagation vector
d) Electric and magnetic vectors in a plane wave poynting vector

Books:

Halliday, D., Resnick, R., & Walker, J., Fundamentals of Physics extended, 5th Edition, John Wiley & Sons, New York, 1997.

Code: BCS124 Credit Hours:4

Discrete Mathematics

Logic: propositional logic, rules of propositional logic, predicate logic, symbols, tautologies, quantifiers, inference rules, Introduction to Logic Programming.
Recursion: definition, recursive function, examples of recursive functions.

Sets: terminology, operations, set identities.

Counting: sum rule, product rule, pigeon-hole principle, permutations, combinations, using trees in counting, inclusion-exclusion principle, discrete probability.

Trees and Graphs: terminology, binary trees, recursive definition of a binary tree, applications of binary trees, directed and un-directed graphs, adjacency matrix.

Boolean Algebra: Boolean operators and functions, functional completeness, combinational circuits.

Functions and Relations: types of functions, types of relations.

Regular Expressions: regular grammar, context-free grammar.

Books:

K. H. Rosen, Discrete Mathematics and its Applications, 5th Edition, McGraw-Hill, 2002.

Code: BCS125 Credit Hours: 3

Pakistan Studies/Islamic Studies

Pakistan Studies

a) Ideology of Pakistan in the historical perspective
b) Two nation theory
c) Pakistan movement
d) Creation of Pakistan and role of Quaid-e-Azam
e) Initial difficulties
f) Islamization in Pakistan

g) The land of Pakistan

Books:

1. *M. Ikram Rabbani, A comprehensive book of Pakistan Studies, 3rd Edition, The Caravan Press,Lahore, Pakistan,2001.*
2. *I.H. Qureshi, The struggle for Pakistan.*
3. *Waheed-uz-Zaman, Towards Pakistan.*
4. *K.K. Aziz, The making of Pakistan.*

Islamic Studies

a) Definition and meaning of Islam
b) The place of Quran in Islamic World Nations
c) The Hadith
d) The Political System of Islam
e) The Legal System of Islam
f) Principles of an Islamic state and chances of their people

Books:

1. *S. Abul A'la Maududi, The Islamic Law and Constitution,12th Edition, Islamic Publications(Pvt) Ltd, Lahore,Pakistan, 1997.*
2. *Farkhanda Noor Muhammad, ISLAMIAT for Students, 2nd Edition, Ferozsons(Pvt) Ltd.Lahore, Pakistan, 2000.*
3. *Anwar H. Syed Islam, Politics and National Solidarity.*
4. *M.A. Hai, A handbook of Islam.*
5. *Al-Quran(a contemporary translation).*
6. *Ishtiaq Ahmad, The concept of an Islamic state.*
7. *Dr. Ismail Al Farooqi, Jinnah and Pakistan of Islamic identify.*

Code: BCS231 Credit Hours: 3

Digital Logic Design

Numbering Systems

a) Number Representation, Conversion, and Arithmetic in/between Binary, Octal, Decimal, Hexadecimal Numbering Systems
b) Complements and Complement Arithmetic, Binary Coding Schemes, Binary Logic, ICs

Boolean Algebra and Logic Gates

a) Definitions, Theorems and Properties, Boolean Algebra theorem Proving, Duality Principle
b) Boolean Functions, Standard and Canonical Forms of Boolean, Functions, Conversion between standard and canonical forms, Logic Gates, Implementation of Boolean Functions with AND, OR, and Not Gates.

Simplification of Boolean Functions

Simplification by Algebraic Manipulation, Map and Tabulation Methods, Boolean Function Implementation with NAND and NOR Gates.

Combinational Logic

a) Design and Analysis Procedures for Combinational Circuits, Designing and Analyzing Adders, Subtractions, and Code Converters.
b) EOR and ENOR Functions, their Applications and Implementations

Combinational Logic with MSI and LSI

a) Binary Parallel Adder, Decimal Adder, BCD Adder, Magnitude Comparator, Decoders, Demultiplexors, Encoders, Multiplexers, ROMs, PLAs
b) Implementation of Boolean Function with Decoders, Multiplexers, ROMs, and PLAs.

Sequential Logic

a) Introduction, Latches, Flip Flops, Types of Flip-Flops, Synchronous and Asynchronous Flip-Flops, Master-Slave and Edge-Triggered Flip-Flops.
b) Design and Analysis Procedures for Sequential Circuits, Designing and analyzing Counters and Other Sequential Circuits, State Machines.

Registers, Counters, and Memory Unit

Registers, Counters, Timing Sequence and Memory Unit.

Asynchronous Sequential Logic

a) Analysis Procedure, Circuits with Latches, Design procedure
b) Reduction of State and Flow Tables, Race Free State Assignment

Digital Integrated Circuits

a) Bipolar Transistor Characteristics, RTL and DTL Circuits
b) Transistor-Transistor Logic, Emitter-Coupled Logic(ECL)
c) Metal Oxide Semiconductor (MOS), CMOS

Books:

Morris Mano, Digital Logic and Computer Design, Prentice Hall, 1992.

Code: BCS232 Credit Hours: 4

Database-I

Database Foundation

a) Introduction, Data and Information, Components, Advantages
b) Data Association, Entities, Keys and its Types, Attributes
c) Data Associations, Data Structure Diagram

E-R Model

a) Basic Constructs (Symbols), Degree of Relationships, Cardinality, Gerund

b) Modelling time dependent Data Super Types, sub Types

Data Models

a) Hierarchical, Network, Relational Comparison of all Data Models

b) Relation, Characteristics of Relation, Converting E-R Model into Relations.

Normalization (1NF, 2NF, 3NF, 4NF, 5NF)

Relational Algebra, Relational Calculus

Database Design (Conceptual Design, Physical Design)

SQL

a) Introduction: Creating, Altering, and Deleting table
b) Inserting, Updating, and Deleting Rows, Querying Tables
c) SQL Functions.
   1. Arithmetic: Group (AVG, COUNT, MAX, MIN,SUM)
   2. DATE, Special Functions (IN, BETWEEN, LIKE, NULL)
d. Managing Multiple Tables

Books:

1. *Jeffery A. Hoffer, Modern Database Management, 4th Edition, The Benjamin/Cummings Publishing Company Inc, 1994.*
2. *Oracle Developer/2000 Forms 4.5, 2nd Edition. SAMS Publishing, 1997.*

Code: BCS233 Credit Hours: 3

Data Structures

Introduction

Linear Structures: Arrays

a) Linked implementation
b) Odd shaped Arrays
c) Right Triangular
d) Isosceles triangular

Notations and their conversion (using stack)

Stacks & Queues

a) Stacks
b) Queues
c) Basic Operations

Lists

a) Linked Lists
b) Types of Linked Lists

Trees

a) Linked implementation
b) Binary Trees
c) B-Trees

Trees Traversal

a) Basic Operations
b) Traversals Sets

Graphs

a) Representation of directed and undirected graphs
b) Traversals
c) Minimum cost spanning tree

Files

a) File organizations: Sequential
b) Indexed Sequential
c) Direct (Hashing)
d) Inverted
e) Use of B-Tree Indexes
f) Merging files

Sorting & Searching

a) Internal Sorting
   1. Selection
   2. Insertion
   3. Quick, Using recursion & stack
   4. Tree
   5. Heap

b) External Sorting
   1. Balanced Merged Sort
   2. Poly-phase Merged Sort

c) Searching
   1. Binary Search
   2. Sequential Search for ordered and unordered list

Books:

1. *Jean-Paul Tremblay, Paul G. Sorenson, An Introduction to Data Structures with Applications, McGraw Hill Inc, 1984.*
2. *Aaron M. Tenebaum, Data Structures, 2nd Edition, Prentice Hall, 1995.*

Code: BCS234 Credit Hours: 3

Business Communications

An Overview of Communication

a) Defining communication, importance of communication concepts of communications.
b) Barriers of communication, Nonverbal communication, Principles of effective communications.

Business Communication in Context

a) Business communication and the global context.
   1. Background to international communication, and the national cultural variables.
   2. Individual cultural variables.

b) Business communication and ethics Influences on personal ethics, communication and ethical issues.

Business communication and technology

a) Managing information with in organization
   1. History of technological developments.
   2. Challenges to the organization made by the new technologies.

b) E-mail and other technologies for communication

   1. Defining e-mail, using e-mail, understanding how email works.
   2. Understanding the internet, Establishing Security, Voice mail, Group ware.
   3. CD-ROM Database, Teleconference, Faxes.

c) Managing information our sides the organization

Message design

a) Process of preparing effective business messages
   1. Five planning steps, Basic organizational plans, Beginning and ending.
   2. Composing the message.

b) The appearance and the design of business message business letters, memorandums, special timesaving message media

c) Good news and natural messages

d) Organizational plan favorable Replies, neutral messages

Written communication: Major Plans for letters and MEMOS

a) Bad/+

b) 123-News messages
   1. The right attitude, plans for bad news messages.
   2. Negative replies to request, Unfavorable unsolicited messages

c) Persuasive written messages.
   1. Organization of persuasive messages.
   2. Persuasive request persuasive sales letters.

Written communication: Reports

a) Short reports
   1. Suggestions for short reports, information memorandum reports.
   2. Analytical memorandum reports, letter reports.

b) Long formal reports (prefatory and supplement selection, presentation of long reports

c) Proposals (Purpose , kinds, parts, sort proposals, long formal proposals)

d) Writing style and appearance

Strategies for oral communication

a) Strategies for successful speaking and successful listening
   1. Strategies for improving oral presentation, Strategies for reducing stage fright.
   2. Strategies for improving listing skills.

b) Strategies for success informative and persuasive speaking

Books:

Herta A Murphy, Herbert W. hildebrandt, Jane P. Thomas,Effective business communication, 7th edition, McGraw Hill/Irwin, 1997.

Code: BCS235 Credit Hours: 3

Electronics

Direct Current Circuits

a) Joules' Law
b) Circuit Analysis
c) Kirehhoff's Rules
d) Wheatstone Bridge

Alternating Currents

a) Sinusoidal Signals, Frequency, amplitude and phase, uns, value, power factor.
b) Capacitive reactance
c) Inductive reactance
d) RL Filter
e) RC Filter
f) Diffenitiating and integrating factor
g) Transient currents
h) Transition and Diffusion Capacitance
i) Reese Recovery Time
j) Zener Diode
k) Light Emitting Diode.

Diode Applications

a) Load Line Analysis
b) Series/Parallel and Series-Parellel Configurations.
c) AND/OR Gates
d) Half wave and full wave rectifier.
e) Clippers and clampers
f) Voltage multiplier circuits, junction.

Transistor

a) Transistor Construction
b) Transistor Operation
c) Different Configurations
d) Transistor amplifying action
e) Limits of Operations
f) DC Biasing
g) Fixed Bias Circuit
h) Emitter Stabilized bias circuit
i) Voltage Divider biased
j) BJT transistor Modeling
k) BJT small signal analysis

Amplifiers

a) Differential and Common mode operation
b) Op-amp basic
c) Op-amp application

Books:

James J. Brophy, Basic Electronics for Scientists, 5th Edition, McGraw Hill Publishing Company Inc, 1990.

Code: BCS241 Credit Hours: 3

Databases-II

Database Administration

a) Introduction, Layers of Database Administration, DBA Functions and Responsibilities

Database Integrity

a) Introduction
b) Integrity Rules
    1. Entity Integrity
    2. referential
    a) Insertion Rule
    b) Deletion Rule (Restrict, Nullity, Cascade)
    c) Range of values, Not Null, Selection Based Entry(Radio Button, Check Boxes LOV)

Database Security

a) Introduction
b) Physical Security, (Locks, Logbooks, Staff, Categorization)
c) Database Security
    1. View, authorization, Table Subject, Object, Privileges, User defined Procedures
    2. encryption

Database Recovery

a) Introduction, Reasons of Database Failures, Database Recovery Facilities
    1. Backup Logs (Transaction Log, Database Change Log)

b) Database Recovery Methods (Restore, Roll Forward, Roll Backward)
c) Transaction processing

Database Concurrency

a) Introduction, the problem of Lost Updation
b) Concurrency Control Methods (Optimistic Approach, Pessimistic Approach)
c) Managing the Deadlock, Transaction Integrity

Distributed Databases

a) Introduction, Types of Distributed Databases

b) Advantages and Disadvantages of Distributed Database

Object Oriented Databases

a) Introduction to Object Oriented Paradigm
b) Differences in Object Model and Design
c) Object oriented Analysis and Design
d) Cost and benefits of Object data bases

Books:

1. *C.J. Date, An introduction to Database, 6th Edition, Addison Wesley Company, 1983.*
2. *Jeffrey A Hoffer, Database Management, 4th edition, The Benjamin/Cummings Publishing Company Inc, 1994.*
3. *Thomas M. Connolly, Carolyn E. Begg, Database Systems: A Practical Approach To Design, Implementation And Management, 4th Edition, Addison Wesley Publishing Company, 2004.*
4. *Tools: Any SQL based DBMS.*

Code: BCS242 Credit Hours: 4

Programming Language-II(Visual C++)

Templates

a) Function and Class Templates, Overloading Templates, Overridding Templates
b) Templates and Inheritance, Templates and Friend Functions

Exception Handling

Basic Bug Traps, C++ Exception Handling and Resumption

Basic GUI Programming

1. Documents and Views, Status Bars and Tool Bars, Dialog Boxes, Controls, Property Pages and Sheets, Drawing Functions, Menus
2. Bitmaps and Bit Operations, Printing and Previewing

ActiveX Applications and Controls

Developing ActiveX Controls and Applications

Socket Programming

Communication Among Processes

Process Synchronization, Exchange Data through Pipes and Shared Memory, Clipboards, Using OLE

Advance Programming Techniques

Database Access, SQL, Multithreading, MFC Library

Debugging

Understanding Debugging, Basic Debugging Operations

Books:

1. *Ivor Horton, Beginning Visual C++6, New Edition, Wrox. Publications, 1998.*
2. *Michael J.Young, Mastering Visual C++6, Sybex Inc, 1998.*

Code: BCS243 Credit Hours: 4

Operating Systems

Introduction

a) Definitions

b) Evolution
c) Structure and Functions

Process Management

a) Processes, Process States, Process State Models
b) Process Synchronization and Inter-Process Communication. Classical IPC Problems
c) Process Scheduling
d) Process Management in Windows NT and UNIX

Memory Management

a) Real Memory Organization and Management
b) Virtual Memory Organization: Paging, Segmentation, Combined Paging and Segmentation
c) Virtual Memory Management: Placement, Replacement, and Fetch Strategies. Working Set Theory, Virtual Memory Management with Working Sets.

File Systems

a) Files
b) Directory Systems
c) File System Implementation
d) Security
e) Protection Mechanisms

Input/Output Management

a) Principles of 1/O Hardware
b) Principles of 1/O Software
c) Disks
d) Clocks
e) Terminals

Deadlock

a) Resources
b) Deadlock

c) Deadlock Detection

d) Deadlock recovery
e) Deadlock Avoidance
f) Deadlock Prevention
g) Other issues

An overview of major Operating Systems

a) Unix
b) NT
c) Windows

Distributed Operating Systems

a) Network Operating Systems
b) Distributed Operating System

Case Studies

a) Unix
b) NT
c) Windows

Books:

1. *Deitel, H.M, An Introduction to Operating System, 2nd Edition, Addison Wesley Publishing Company, 1983.*
2. *Collin Ritchie, Operating Systems, 2nd Edition, BPB Publications, 1998.*
3. *Tenenbaum, Modern Operating Systems, 2nd Edition, Prentice Hall, 1998.*

Code: BCS244 Credit Hours:3

Computer Organization and Assembly Language Programming

Computer Organization

Data and Instruction Representation.

Assembly Language Programming

a) ASCII Code Assembler Directives vs Machine Instructions.
b) Keyboard Input and Screen Output.
c) Addressing & Instruction Formats/types
   i. Op-code encoding.
   ii. Addressing modes.
   iii. Addressing types.

d) Detailed study of different/Instruction types-I
   i Data-transfer instructions.

   ii Data transfer instructions.

   iii Arithmetic instructions.

   iv Logical instructions, program control instructions.

e) Conversion between ASCII Strings and Binary Numbers
f) Stack Operations
g) Debugging
h) Interrupts
i) Macros
j) Video Output
k) Disk 1/O

Books:

Kip R. Irvine, Assembly Language for IBM PC, 2nd Edition, Macmillan Publishing Company, 1993.

Code: BCS245 Credit Hours: 4

Data Communications and Networking

Data transmission & Networking Concept

a) Introduction to data communication, advantages of digital communication, A communication Model.

b) Codes for digital signal transmission
c) Parallel and serial transmission
d) Synchronous and Asynchronous Transmission
e) Baseband and Broadband Transmission
f) Simplex, Half-duplex and Full-duplex transmission
g) Modems, types of Modems, properties of modems
h) Topologies: Bus,Star,Ring,Tree,Mesh.
i) Need of Networks, Peer- to-Peer networks, Client- Server networks, Hybrid networks
j) Circuit Switching, Message Switching and Packet Switching

Transmission Impairments

a) Attenuation
b) Delay Distortion
c) Noise
d) Channel Capacity

Transmission Media

a) Guided Transmission Media, Twisted Pair, Coaxial Cable and Optical Fiber.
b) Wireless Transmission- Terrestrial & Satellite Microwave and Broadcast Radio

Data Encoding

a) Digital and Analog transmission.
b) Digital Data & Digital Signals
c) Digital Data & Analog Signals
d) Analog Data & Digital Signals
e) Analog data & Analog Signals

Data Communication Interface

a) Line Configuration, Interfacing, Null Modem
b) Point to point and multipoint link

Data Link Control

Flow Control Techniques:

a) Polling Selection, Request to send/clear
b) XON/XOFF
c) Stop & Wait
d) Sliding Window

Error Detection/correction & Control Techniques

Error Detection and Correction Techniques:

1. Parity bit method
2. Vertical and horizontal redundancy checking
3. Cyclic redundancy checking(CRC).

Error Control Techniques:

1. Stop and Wait ARQ
2. Go-Back-N ARQ
3. Selective-Reject ARQ
4. High Level Data Link Control Protocols (HDLC)

Multiplexing

a) Frequency Division Multiplexing
b) Synchronous and Statistical Time Division Multiplexing

Internetworking Devices

a) Hubs
b) Switches
c) Routers
d) NICs

Network Models

a) TCP/IP Model
b) OSI Model

LAN Architectures

a) Ethernet, Token Ring, FDDI, Token Bus, ARCNet, AppleTalk.

Books:

1. *William Stallings, Data and Computer Communications, 7th Edition, Prentice Hall, 2003.*
2. *Behrouz A.Forouzan, Data Communications and Networking, 3rd Edition, McGraw Hill, 2003.*
3. *Andrew S. Tenanbaum, Computer Networks, 4th Edition, Prentice Hall, 2002.*
4. *Dr. D.C.Agarwal, Computer Communication and ISDN systems, 1st Edition, Khanna Publishers, 1989.*

Code: BCS351 Credit Hours: 3

Internet Programming

HTML(Hypertext Markup Language)

a) Internet, Web and HTML Fundamentals
b) What is HTML
c) The World Wide Web and Web Servers
d) Working of Web Browsers
e) HTML's Role on the Web
f) Way of launching the Web Site

Creating Static Web Pages with HTML

a) Creating a Web page and entering Text
b) Changing and Customizations
c) Display Text in List
d) Adding Graphics into Web Pages
e) Hypertext and Creating Links
f) Issuing Links with other HTML Tags

Advance HTML

a) Tables, Forms, Images
b) Frames
c) Multimedia Objects

Java Script

a) Data types
b) Control Structures
c) Object & Function
d) Event Handling

VB Script

Introduction, Data Types, Syntax, Controls, etc.

Active Server Pages

Personal Home Page

Common Gateway Interface(CGI) Script

Database Connectivity

a) Using ASP
b) Using CGI
c) Using PHP

Books:

1. *Thomas A. Powell, HTML The Complete Reference, 2nd Edition, McGraw Hill, 1999.*
2. *Ann Navarro, Todd Stauffer, HTML by Example, 1st Edition, Que Corp, 1999.*
3. *Andrew Wooldrige, Mike Morgan, Mona Everett, Scott J. Walter, Special Edition Using Java Script, Que Corp, 1997.*

Code: BCS352 Credit Hours: 3

Artificial Intelligence

Basic Concepts: Intelligence, Artificial Intelligence, Branches of Artificial Intelligence.

Tools: Prolog language, LISP language, Introduction to Small Talk, Expert System Shells.

Techniques: Searching (Blind search, knowledge-directed search); Knowledge Representation (Logic, Rules, Semantic Networks, scripts).

Applications: Natural Language Processing, Expert System, Speech Processing, Computer Vision, Robotics, Neural Networks, Machine Learning.

Books:

1. *D. Partridge, Artificial Intelligence applications in the future of software engineering, International Edition, Halsted Press, 1986.*
2. *Elaine Rich, Kevin Knight, Artificial Intelligence, 2nd Edition, McGraw Hill 1990.*
3. *Steven L. Tanimoto, The Elements of Artificial Intelligence: An Introduction using LISP, W.H.Freeman and Company, New York, 1987.*
4. *G.A. Orban, H. H. Hagel, Artificial and Biological Vision Systems, Springer-Verlag, 1992.*

Code: BCS353 Cred Hrs: 3

Analysis of Algorithm

Introduction, Properties of algorithms, features of algorithms, factors influencing the performance of algorithms (not in control of the programmer), Analysis of Algorithms, classification of algorithms, computational complexity, Asymptotic Notations, usefulness and limitations of the Asymptotic notation, Basic Recurrences, Recurrence Solutions, Factors influencing the execution time of an algorithm, some examples to calculate the T(n) of algorithms (including examples from searching and sorting), implementation of algorithms, rules for implementation, empirical analysis, Introduction to Generation functions, system approach, algorithms and systems, dynamic programming, greedy algorithms, divide and conquer approach.

Books:

1. *Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, 2nd Edition, The MIT Press, 2001.*
2. *Robert Sedgewick, Philippe Flajolet, An Introduction to the Analysis of Algorithms, 1st Edition, Addison Wesley Publishing Company, 1995.*

Code: BCS354 Cred Hrs: 4

Programming Language III

Introduction to Java

a) Introduction, Data Types, Syntax etc.
b) Writing Simple Java Console Application

Applets

a) Introduction to AWT and Applets, Use of AWT components in Java Application
b) Writing Simple Applets

Servlets

a) Introduction to Servlets, Servlets Life Cycle
b) Developing Basic Servlets
c) Using doPost, doGet, Service according to HTML Form Methods
d) SSI (Server Side Include)
e) Session Management

Advanced Java

a) Packages and Interface
b) Exceptions

Java Class Libraries

a) Threads
b) Writing Java Application
c) The Java Class Libraries

Books:

1. *Jamie Jaworski, Java Developer's Guide, Macmillan Computer Pub. 1996.*
2. *Dustin R. Callaway, Inside Servlets : Server-side Programming for Java Platform, 2nd Edition, Addison Wesley Publishing Company, 2001.*

Code: BCS355 Cred Hrs: 3

Software Engineering-I

Introduction

a) The Evolving Role of Software
b) Software: A Crisis on the horizon, Software Myths

The Process

a) Software Engineering- A Layered Technology
b) The Software Process. Software Process Models, The Linear Sequential Model
c) The prototyping Model, The Red Model, Evolutionary Software Process Models

Project Management Concepts

The Management Spectrum, People, The Problem, The Process.

System Engineering

a) Computer-Based System, the Modeling Engineering Hierarchy
b) Information Engineering, Information Strategy planning, Business Area Analysis
c) Product Engineering, Modeling The system Architecture
d) System Modeling and Simulation, System Specification

Analysis Concepts and Principles

a) Requirements analysis, Communication Techniques, Analysis Principle
b) Software Prototyping, Specification Review

Analysis Modeling

a) A Brief History, the Elements of the analysis Model, data Modeling
b) Functional Modeling and information Flow, Behavioral Modeling
c) The Mechanics of STRUCTURED Analysis, The Data Dictionary
d) An Overview of Other Classical Analysis Methods

Design Concept and Principle

a) The Design process, Design Principles, Design Concepts, Effective Modular Design
b) Design Heuristics for Effective Modularity, the Design Model, Design Documentation

Design Methods

a) Data Design, Architectural Design, The Architectural Design Process
b) Transform Mapping, Transaction Mapping, Design Post Processing
c) Architectural Design Optimization, interface Design, Human Computer Interface Design
d) Interface Design Guidelines, Procedural Design

Software Testing Methods

a) Software Testing Fundamental, test case Design, White Box
b) Basic path testing, Control Structure Testing, Black Box Testing
c) Testing for Specialised Environments
d) Strategies approaches to software testing and strategic issues

e) Unit testing and Integrating testing.

Books:

Roger Pressman, Software Engineering, 6th Edition, McGraw Hill, 1997.

Code: BCS356 Credit Hrs: 3

Network Strategies

Switching circuit and packet switching

a) switching networks, circuit-switching networks, switching concepts
b) Routing in circuit in switched networks, control signaling
c) Packet switching principles, routing , congestion control,X.25 protocols

Frame relay and asynchronous transfer mode (ATM) :

a) beak ground ,frame relay protocol architecture frame relay ,call control
b) user data transfer, network function ,congestion control,
c) protocol architecture ,ATM logical connection ,ATM cells ,transmission of ATM cards
d) ATM adaption layer , traffic and conjunction control
e) ISDN and broad band ISDN , channels, user access ,isdn protocol, broad band protocol

Internetworking and network security:

a) principles of internetworking connectionless and connection oriented internetworking
b) the internet protocol ,routing protocol,IPv4,Ipv6(IPng),ICMPv6

c) security requirements and attacks, privacy with conventional encryption message
d) authentication and hash function ,public key encryption and digital signatures
e) NetBIOS Names, NetBIOS background and names

Protocols and architecture:

a) Internet protocol address resolution protocols(ARP)
b) Internet control message protocol(ICMP)
c) Internet group management protocol(IGMP)
d) Border gateway protocol (BGP).
e) Routing information protocol (RIP), Open shortest path first (OSPF),

Transport protocol

a) Transport layer , transport services, protocol mechanisms
b) Transmission control protocol, TCP header
c) User data gram protocol, UDP header
d) Ports and sockets

Network/Data Link Control protocol and Microsoft networking protocol suite:

a) High level data link control protocols (HDLC), Serial Line Internet Control protocol (SLIP), Point –to-point protocol (PPP)
b) Application /file System driver, Transport driver interface
c) Protocol (TCP/IP, NW link, NetBEUI, AFP, DLC), network driver interface specification (NDIS)

Distributed application protocol:

a) Abstract syntax notation one (ASN 1), network management –SNMPV2
b) Electronic mail –SMTP and MIME

URL and URI

a) Uniform resource locators (URL) and Universal resource identifiers (URI).

HTTP, FTP, TFTP:

a) Hypertext transfer protocol(HTTP),Dynamic host configuration protocol (DHCP) File transfer protocol(FTP),TFTP

Books:

1. *William Stallings, Data and Computer Communications, 5th Edition, Prentice Hall, 1994.*
2. *Andrew S. Tanenbaum, Computer Networks, 2nd Edition, Prentice Hall Inc, 1995.*

Code: BCS361 Credit Hours: 3

Computer Architecture

Computer Architecture Introduction

a) Introduction to Computer Architecture
b) Evolution of computers (form Mechanical to Electronic)

Basics of Computer Architecture

a) Hardware and firmware
b) Basics of computer architecture
c) Introduction
d) Computer structure
e) Type of computers and future trend computer instruction se

Detailed Study of different Instruction types

a) 1/0 instructions reduced instruction sets computers
b) case study: RISC (University of California Berkeley)

Execution

a) Introduction to Execution unit (EU)
b) Register sections
c) General register design
d) Combinatorial Design of Adders

ALU Design & BIT SLICE Processor Control Unit

a) ALU design
b) BIT SLICE Processor Control Unit
    1. Basic concept
    2. Design Methods (Hardware control design and micro programmed control unit)

Memory Organization

a) Primary memory design (ROM/RAM)
b) Secondary memory (Hard disk, floppy disk, CD-ROM) Cache Memory, Virtual Memory Management

Input/Output Design

a) Cache Memory
    1. Associative mapping
    2. Direct mapping
b) Segmentation and Mapping, and input / output design
    1. Programmed I/O
    2. Standard I/O unconditional programmed I/O
    3. Interrupt I/O
    4. Computer Organization
    5. Microprocessor and its supports circuitry
    6. Peripheral devices

Books:

1. *M. Moris Mano, Modern Computer architecture, 3rd Edition, Prentice Hall, 1992.*
2. *William Stallings, Computer Organization and Architecture, 3rd Edition, Macmillan Publishing Company, 1993.*

Code: BCS362 Credit Hours: 3

Numerical Analysis

Error Analysis

a) Definition of error, Sources of error, Significant digits, Precision and accuracy
b) Effect of Rounding errors in arithmetic operations, Numerical Cancellation
c) Evaluation functions by series expansion and estimation of errors

Non-Linear Equations

a) Methods to solve Non-Linear equations, Simple interactive procedure

b) Acceleration of convergence, Newton's Raphons Methods, the Bisection method
c) The Secant methods, methods of False portion, Multiple Roots, Zeros of Polynomials

Linear System of Equations

a) Basic concept, Methods to solve a system of linear equations, Cramer's rule
b) Guassian elimination method, Triangular decomposition method
c) Triangular decomposition for symmetric matrices
d) Solution of Tridiagonal system of equation, Jacobi's method, Guass-seidel method

Finite Differences

a) Difference table, Detection and correction of error in a difference table
b) Forward difference operator, Backward difference operator, Central difference operator
c) Shift operator, Mean operator, Relationship between operators

Interpolation

a) Choice of a / suitable interpolation Formula
b) Type of interpolation Formulas for Equally-paced data points
c) Type of interpolation Formulas for Unequally – spaced data points
d) Newton's Forward Difference interpolation Formula
e) Newton's Backward Difference interpolation Formula
f) Interpolation with Central Difference Formula, Stirling's interpolation Formula
g) Bessel's Interpolation Formula, Everett's interpolation Formula
h) Guassian Interpolation Formula, Lagrange's Formula Iterative, Interpolation Method
i) Error Estimation in Interpolation

Numerical Differentiation

a) Derivation of Differentiation Formulas, Relationship Between Operator E and D

b) Derivatives Using Newton's Forward Difference Formula
c) Derivatives Using Newton's Backward Difference Formula

d) Derivatives Using Central Difference Formula

Numerical Integration-I

a) Derivative of Integration Formulas, Trapezoidal Rule, Simpson's 1/3rd Rule
b) Boole's Rule, Weddle's Rule, Estimation of error in some Newton-cotes formula
c) Error in Trapezoidal Rule, Error in Simpson's 1/3rd Rule, Automatic Subdivision of Interval

Numerical Integration-II and Ordinary Differential Equation

a) Repeated use of Trapezoidal Rule, Romberg's Integration Method
b) Ordinary Differential Equations
   1. Classification of differential equations, Categories of ODEs
   2. Linear and Non-Linear ODEs, Boundary Conditions, Methods to solve ODEs,
   3. Numerical Methods to solve ODEs, Picard's Method
c) Taylor Series Methods, Euler's Methods and bariations

Ordinary Differential Equations

a) Runge-Kutta Methods, Predictor-Corrector Methods
b) Milne-Simpson Predictor-corrector Method, Adams-bashforth
c) Adams-Moulton Method
d) Solution of simultaneous and Higher-order ordinary differential equations
e) Solution of First order Simultaneous differential equations, Solution of an nth order differential equations

Books:

Richard L. Burden, Faires J. Douglas, Numerical Analysis, 5th Edition, PWS-KENT Publishing Company, 1993.

Code: BCS363 Credit Hours: 3

Automata Theory

Regular Languages

Regular Grammars

Finite-State Automata

Compiler-Writing Tools

Lex, Yacc, etc

Transducers and Relationship among Them

Context-Free Languages and Grammars

Language Recognition

Parsers

Properties of Formal Languages

Turning Computability and Undesirability

Books:

1. *Dean Kellye, Automata and Formal Languages: An Introduction, 1st Edition, Prentice Hall, 1998.*
2. *Dexter C.Kozen, Automata and Computability, 1st Edition, Springer Verlag, 1987.*
3. *M.W.Shields, An Introduction to Automata Theory (Computer Science Texts), Alfred Waller Ltd, 1988.*

Code: BCS364 Credit Hours: 4

Computer Graphics

Fundamentals

a) Introduction, Pints and Lines
b) Planes and Co-Ordinates, Lines Segments

Fundamentals (Continued)

a) Perpendicular Lines, Vectors, Pixels and Frame Buffers
b) Vector Generation Character Generation, Displaying The Frame Buffer

Graphic I/O Device

a) Calligraphic Refresh Display
b) Raster Refresh Display
c) Keyboard
d) Graphic Tablet

Drawing Algorithms

a) Lines
b) Bresenham's Algorithm
c) Curves
d) Rectangle
e) Rounded Rectangles

2-D Transformations

a) Uses for Transformations

b) Modeling, Mapping

c) 2-D Co-Ordinate Transformations

d) Matrix Representation

e) Homogeneous Co-Ordinates

3-D Transformations and Projections

a) Parallel and Perspective Projections

b) Rotations

Scan Conversion Techniques

a) Real – Time Scan Conversion
b) Run – Length Encoding

Polygons

a) Inside Test
b) Algorithm for Filling Polygons
c) Seed Fill Algorithms
d) Inclusion of Polygons as Graphics System Primitive

Clipping and Windowing

a) Viewing Transformation
b) Specification of Window and View Port
c) Clipping Algorithms
d) Sutherland-Cohen Algorithm for Clipping Lines
e) Sutherland-Hodgman Algorithm for Clipping Polygons
f) Addition of Clipping
g) Windowing to Graphic System

Books:

Harrington, Computer Graphics: A Programming Approach, McGraw Hill, 1983.

Code: BCS365 Credit Hours: 3

Software Engineering-II

Object Oriented Analysis and Design

Introduction

a) Introduction & Definitions
b) OO Modeling Concepts
c) OO Developments

Modeling as a Design Technique

a) Object Modeling Technique

Object Modeling

a) Objects & Class
b) Links & Associations
c) Generalization & Inheritance
d) Grouping Constructs
e) Aggregation
f) Abstract Class
g) Multiple Inheritance, Meta Data, Candidate Key

Dynamic Modeling

a) Events & States.
b) Operations, Nested State Diagram
c) Concurrency, Advanced Dynamic Modeling Concepts

Functional Modeling

a) Functional Models, DFD
b) Specifying Operations, Constraints
c) Relation of Functional to Object and Dynamic Model

Design Methodology

a) Methodology review
b) OMT as Software Engineering Methodology
c) OMT Methodology, Impact of OO approach

System Design

a) Overview of System Design
b) Breaking of System into Sub Systems
c) Identifying Concurrency
d) Allocating Subsystems to Processors and Tasks
e) Management of Data Store
f) Handling Global Recurs
g) Choosing Software Control Implementation
h) Handling Boundary Conditions
i) Settling Traded-off Priorities
j) Common Architectural Framework
k) Architecture of ATM System

Implementation

a) Form Design to Implementation
b) Implementation using programming languages
c) Implementation using Database System
d) Implementation using Outside a Computer

OO Testing

a) Testing OOA and Models
b) OO Testing Strategies
c) Test Case Design for OO Software
d) Testing methods applicable at class levels
e) Inter class test case design

Object Diagram Compiler

a) Background
b) Problem Statement
c) Analysis
d) System Design
e) Object Design
f) Implementation

Books:

1. *James Rumbaugh, Object Oriented Modeling and Design, 6th Edition, Prentice Hall International, 2000.*
2. *Craig Larman, Applying UML and Patterns: An introduction to Object-Oriented analysis and Design, 2nd Edition, Prentice Hall International, 2001.*

3. *James R.Rumbaugh, Michael R.Blaha, William Premerlani, Frederick Eddy, William Lorensen,Object Oriented Modeling and Design with UML, 2nd Edition, Prentice Hall, 2004*.

Code: BCS471 Cred Hrs: 3

Compiler Construction

Compiler and Interpreters

a) Compiler
b) Interpreter

Compilation Process

Organization of Compiler

Analysis

a) Lexical
b) Syntax
c) Semantic

Symbol Tables

Recognizer

a) Top-Down Recognizer
b) Bottom up recognizer

Error Detection and Recovery

Storage Allocation

Code Generation Code Optimization

a) Code Generation
b) Code Optimization

Books:

1. *Elder and John, Compiler Construction A Recursive Descent Model, Prentice Hall International, 1994.*
2. *Alfred V. Aho, Principles of Compiler Design, Addison Wesley, 1977.*

Code: BCS472 Cred Hrs: 3

Wireless and Mobile communications

Principles of wireless communication

1) Technologies used for wireless communications.

2) Major wireless standards.

3) The problems characterising wireless and mobile computing.

4) Limitations of the wireless technology.

Wireless networks

1) The main components of a Wireless LAN.
2) Modes of Operation for Wireless LANs (Infrastructure Mode, Adhoc Mode).
3) Compatibility of different technologies.
4) Main components of a satellite-based network.

Wireless LANs Standards

802.11 and its flavors (802.11a, 802.11b, 802.11g), HIPERLAN.

Characteristics of radio propagation

Fading, Multipath propagation

.

Narrowband digital modulation

The need for modulation. Binary and multi-level (M-ary) amplitude-shift keying (ASK), frequency-shift keying (FSK) and phase-shift keying (PSK).

Mobile computing

Introduction, need for mobile computing.

Radio Channel Characterisation

Multipath propagation, Co-channel interference, Exponential power delay profile, Propagation effects - scattering, ground reflection, fading, Log-normal shadowing, Coherence Bandwidth.

PHY Layer techniques

Wideband modulation techniques to cope with intersymbol interference (Diversity, Spread Spectrum, Frequency Hopping, Direct Sequence, Adaptive Equalisation, Orthogonal Frequency Division Multiplexing).

MAC protocols

MAC protocols for digital cellular systems such as GSM. MAC protocols for wireless LANs such as IEEE802.11 and HIPERLAN I and II. The near far effect. Hidden and exposed terminals. Collision Avoidance (RTS-CTS) protocols.

The Cellular Concept--System Design Fundamentals

Frequency reuse, Reuse distance, Cluster size, Channel assignment strategies, Handoff strategies, Co-channel interference and system capacity, Trunking and grade of service

Wideband CDMA concept/principles

Example:-Global System for Mobile W-CDMA(3G) UMTS.

Protocols supporting mobility

1) The functions of the main protocols for mobile stations

a) Mobile network layer protocols such as mobile-IP, Dynamic Host Configuration Protocol (DHCP).
b) Mobile transport layer protocols such as mobile-TCP, indirect-TCP.
c) Wireless Application Protocol (WAP). Bluetooth.

2) Understand the range of applicability of each protocol

Books:

1. *J.Schiller, Mobile communications, 2nd Edition, Addison-Wesley, 2003.*
2. *T.S. Rappaport, Wireless communications: Principle and Practice, 2nd Edition, Prentice Hall, 2001.*
3. *A S. Tanenbaum, Computer Networks, 4th Edition, Prentice Hall, 2002.*
4. *William Stallings, Wireless Communications and Networks, 1st Edition, Prentice Hall, 2001.*

Code: BCS473 Cred Hrs: 3

Software Project-I

Code: BCS474 Cred Hrs: 3

Digital Signal Processing

Digital Signal Processing and DSP Systems

Need for DSP

Advantages of DSP Systems

A Model of a DSP System

- Input
- Signal Conditioning
- Anti-Aliasing Filters
- Analog-to-Digital Converter
- Processor
- Digital-to-Analog Converter
- Output Smoothing Filter
- Output Transducer
- DSP Processors
- DSP Format Types
- Alternative Formats for Commercial DSP Processors

How Numbers are processed in a DSP

- Polynomials
- Transcendental Functions
- Series Expansions
- Limits
- Integration
- Oscillatory Motion
- Complex Numbers

Acquisition of the Signal

- Sampling Theory
- Sampling Resolution

Aliasing

Reconstruction

Application Examples-Filters

Filtering

Sample Filter

Types of Filters

Bessel

Butterworth

Elliptical

Fourier Series

Insights to be gained from Fourier series

Fourier Series

Nyquist Frequency

Orthogonality and Quadrature

Orthogonality – Basic Building Blocks of DSP

Quadrature – Signal 90 degrees of phase with each other

Transforms

The Z- Transform

DFT – Discrete Fourier Transform

Laplace Transform

Finite Impulse Response Filter – FIR

What is it?

Stability

Cost

Design Methodology

Design Examples

Convolution

Infinite Impulse Response Filter – IIR

What is it?

Stability

Cost

Design Methodology

Design Examples

DSP Tools

Programming Language

Mathematical Tools

Special Purpose Tools

Development Package

DSP and the Future

New User

DSP Directions

Future Technologies

Books:

1. *John G. Proakis, Dimitris Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 3rd Edition, Prentice Hall, 1995.*
2. *Robert D. Strum and Donald E. Kirk, First Principles of Discrete System and Digital signal Processing, Addison Wesley, 1998.*

Code: BCS475 Cred Hrs: 3

E-Commerce Applications and Technologies

Fundamentals of E-Commerce Technologies: An overview of the principles of E-Commerce. The origin and growth of E-Commerce. Technologies that support the development of E-Commerce applications. Business models and strategies for E-Commerce. Legal issues related to E-Commerce such as privacy, consumer rights and intellectual property.

Electronic Payments Systems: Electronic money, electronic contracts, micro-payments, authenticity, integrity and reliability of transactions, the encryption and digital signature techniques available to support secure transactions on the internet.

Cryptography, Information Security and E-Commerce: Symmetric cryptography, Asymmetric cryptography, Digital signature, one-way hashing, zero-knowledge proof, certificate and certificate authority. Secure information infrastructure, virtual private network (VPN), online shopping and payment systems, e-crash. Economic impact. Smart card, steganography, time stamping. Cryptanalysis technology. Authentication protocols, analysis and evaluation.

Distributed Systems and Software: Architectural models for distributed systems, server techniques, remote procedure call and multicast communication, emerging standard and platforms (CORBA, DCOM), distributed transactions, concurrency control, reliability and security issues.

Network and Web Programming: Client-server system design; interprocess communication; sockets; blocking and nonblocking I/O; multithreaded

process; iterative and concurrent server designs; Web programming includes HTML, JAVA, Web page design and construction.

Open Systems for E-Commerce: Introduction to open system standards and protocols. Transaction protocols. Electronic commerce applications using open system and artificial intelligence technologies. Application of intelligent agents for automated transaction processing. Integration of Web programming techniques with information and communication systems.

Project in E-Commerce Technologies: An individual or a team project on E-Commerce technologies. *Project in E-Commerce Technologies are designed to allow students to gain first hand experience in studying and developing real-world systems for E-Commerce. These could be conducted either individually or by teamwork. Possible projects include, but are not limited to: On-line Banking and Financial Systems Supply Chain, Web-based Forecasting and pricing Electronic Payment Systems, Internet Shopping, Virtual Store or Virtual Campus, Electronic Office, Cryptography Servers, Security Fire Wall, Network Management and Quality of Service, Distributed System Technologies in CORBA or DCOM,

HTML(Hypertext Markup Language): Internet, web & HTMLK Fundamentals, The world Wide Web & Web Servers,

Creating Static Web Pages with HTML:

Advanced HTML:

Java Script: Data Type, Control Structures, Object & Function, Event Handling,

VB Script: Introduction, Data Types, Syntax, Control, etc,

Active Server Pages:

Common Gateway Interface (CGI) Script:

Database Connectivity: Using ASP, Using CGI,

Books:

1. *Ann Navarro, Todd Stauffer, HTML by Example, 1st Edition, Que Corp, 1999.*
2. *Andrew Wooldrige, Mike Morgan, Mona Everett, Scott J. Walter, Special Edition Using Java Script, Que Corp, 1997.*

Code: BCS476 Cred Hrs: 3

Expert Systems

Introduction, The Principles of operation of expert systems, State transition model: Expert system models: Planning actions, solving a problem, diagnosis, Producing advice; how to backtrack; a structure for expert system.

The structure of state spaces: connectivity, form; the implicit description of state spaces; search: depth and breadth first search.

Functions for handling lists: functions for search; best first search.

Eliciting knowledge from on expert: interviewing, examples, problem solving, psychological techniques.

Knowledge representation schemes: rules, semantic nets, logic, frames.

Some existing expert systems: MYCIN, DENDRAL, MACSYMA, PROSPECTOR.

Characteristics of knowledge-bases systems, features of problem solvers, Architectural principals.

The choices of system (language/package) production pit falls.

Books:

Gary Marshall, Advanced Students' Guide to Expert Systems, Heinemann Newnes Publications, Oxford, 1990.

Code: BCS477 Cred Hrs: 3

Data Mining & Data Warehousing

Features of a data warehouse. Transformation Process. Multidimensional queries. Data warehousing job functions. Data warehousing operations: Hash join processing, bitmapped indexes, star queries, parallel processing, read-ahead mechanisms. Data Mining: Benefits. Data Mining Techniques: Association, discovery, classification,

clustering. Data Marts: Stand along data marts, subset data marts, multidimensional database. Queries against data mart. Data Mining Tools.

Books:

1. *Alex Berson, Stephen J. Smith, Data Warehousing, Data Mining, and OLAP (Data Warehousing/Data Management), Computing McGraw Hill, 1997.*
2. *George M. Marakas, Modern Data Warehousing, Mining and Visualization: Core Concepts, 1st Edition, Prentice Hall, 2002.*
3. *Margaret H. Dunham, Data Mining: Introductory and Advanced Topics, 1st Edition, Prentice Hall, 2002.*

Code: BCS478 Cred Hrs:3

Management Information System

Information systems, strategic role of information systems, organizations and business process, information management and decision making, ethical and social impact of IS. Computers and IS Software and hardware data resources and telecommunication ensuring quality in information system, enhancing decision making. Accounting, Executive, Decision support, Management Marketing Information Systems. Controlling and managing international information system.

Books:

1. *Kenneth C. Laudon, Jane P. Laudon, Management Information Systems, 8th Edition, Prentice Hall, 2003.*
2. James A. O'Brien, *Management Information Systems: Managing Information Technology in the E-Business Enterprise,6th Edition, McGraw Hill, 2003.*
3. Raymond McLeod, George Schell, *Management Information Systems, 9th Edition, Prentice Hall,2003.*

Code: BCS479 Cred Hrs:3

Distributed Computing

Introduction to Distributed Computing. Architectures and interaction mechanisms. Remote procedure Calling (RPC). SunRPC and its application using Linux. Distributed Object Technology (DOT). Java RMI. COBRA using Java as programming Language. Knowledge representation issues. XML and SOAP. Service Description, Advertisement and Discovery. Load balancing. Transaction management. Fault Tolerance and Recovery Mechanisms. Agent Theory.

Books:

1. *George Coulouris, Jean Dollimore, Tim Kindberg, Distributed Systems: Concepts and Design, 3rd Edition, Addison Wesley, 2000.*
2. *M.L. Liu, Distributed Computing: Principles and Applications, 1st Edition, Addison Wesley, 2003.*
3. *Andrew S. Tanenbaum, Maarten van Steen, Distributed Systems: Principles and Paradigms, 1st Edition, Prentice Hall, 2002.*

Code: BCS481 Cred Hrs: 3

Software Project Management

Introduction to Software Project Management

a) Introduction, the increasing Demand for Software
b) The Role of Management in Software Development
c) Gaining acceptance for New Development Procedures

Software Development Problems

Basic Problem, Risk analysis

Software Development under Contract

a) The Customer-Developer Relationship, the Cost-Pls vs Fixed Price Dilemma
b) Other Customer-Developer Relationships, the Request for Proposal (RFP)
c) The Proposal, F) the Proposal Review and STECTION Process, the Proposal Selection Board
d) Proposal Evaluation Methods Some Additional Proposal Considerations

The Software Development Cycle

a) Variations on a Waterfall Theme, the concept Phase, the Software Requirements Phase
b) The Design Phase, the Implementation Phase, the Integration Test Phase
c) The Atmosphere During the Integration and Test phase
d) Problems During the Integration and Test Phase

The Maintenance Phase

a) The Atmosphere During the Maintenance Phase, Problem During the Maintenance Phase
b) IEEE standrad1074: a standard for Software Life Cycle process
c) The Selection of the Project software Life Model Project Management Processes
d) Pre-Development Process, Development Process, Post-Development process
e) Integral Processes

Managing Software Engineering and handling Large Projects

a) The Software Project Organizational Structure, the Team Structure
b) Basic reporting Techniques, Status Report, Project Status meetings
c) General Guidelines for Managing Software Engineers, Large Need Not Mean Difficult
d) Stepwise Refinement, the Work Breakdown Structure, Handling Large Project

Software Project Management in a Clint/Server Environment

a) An Introduction to Clint/Server Environments, the Network
b) Project Management Advantages and Disadvantage of a Clint/Server Environment
c) Selecting a Clint/Server Environments, Project Management
d) Tips for Managing Clint/Server Environments

Project Support Functions & Software Development Standards

a) Project management Support, Software Configuration Control (SCC)
b) Software Quality Assurance (SQA), Development Standard: the Necessary Evil
c) An Overview of Software Development Standards, US DOS Standard 2167
d) The IEEE Software Engineering Standards, European Software Standards
e) The Ada standards, Other software Development Standards

Project Scheduling and Preparation of Estimates

a) Scheduling: the Problem, the Project Development Plan, Scheduling Activities and Milestones
b) Gantt Charts, PERT Charts and the Critical Path, Scheduling Personnel
c) Scheduling Resources, Monitoring and updating the Schedule
d) Some General Guideline for Scheduling and Planning
e) Estimation the Problem, Project Estimates Stepwise Estimation
f) Estimating New Development, the Constructive Cost Model
g) Function Point Analysis, the Constructive Cost Model (COCOMO)
h) Non-Development Overhead

Books:

Edwin M. Bennatan, Software Project Management: A Practitioner's Approach, 2nd Edition, Computing McGraw-Hill, 1992.

Code: BCS482 Cred Hrs: 3

Natural Language Processing

Monolingual Natural Language Processing:

Difference between natural and formal languages.

Natural language understanding: syntax, semantics, phonetics, morphology, discourse analysis. anaphora/cataphora, cohesion/coherence, ellipses, ambiguity (structural, lexical, transient, discourse).

Natural language Generation: steps in generation.

Natural Language Interfaces.

Machine Translation:

Translation steps: analysis, transfer and generation.

Translation Strategies: direct translation, interlingua and transfer.

Types: Bilingual, Multi-lingual.

Dictionary design: monolingual, bilingual.

Units of translation: word, sentence, discourse.

Some operational and R&D machine translation systems.

Speech translation, benefits of machine translation, integration of machine translation to other fields of computer science, Urdu, Pashto and machine translation.

Books:

1. *Terry Winograd, Understanding Natural language, Addison-Wesley Publishing Company, 1972*.
2. *M. A. Khan, Text Based Machine Translation, 1995*.
3. *Daniel Jurafsky and James H. Martin, SPEECH and LANGUAGE PROCESSING: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Pearson Education,Inc, 2000*.

Code: BCS483 Cred Hrs: 3

Software Project-II

Code: BCS484 Cred Hrs: 3

Digital Image Processing

Introduction

Images as Digital Objects

Images Storage and Display

Image Acquisition

Image Types and Application

Bi-Level Images

Usefulness of Bi-Level Images

Connectivity and Geometry

Measurable Properties of Regions

- Area
- Perimeter
- Length
- Moments – Center of Mass
- Simple Shapes
- Derivative and Complex Shape Measures
- Operations on Bi-Level Image
- Boundary enhancement
- Erosion and dilation
- Sketonization
- Chain Code
- Run-Length Coding

Grey-Level Images

Introduction to Multiple Levels and Histograms

Thresholding

- Selecting a Single Threshold
- Selecting Multiple Threshold
- Grey-Level Modification
- Line and Edges

Geometric Operation

Noise

Color

Classifying and Recognizing Object

Features

Statistical Pattern Analysis

Decision Functions

Template Matching

Structural Methods

1. Representing Relationship
2. Identifying Components

Counting and Classifying Objects

Counting Simple Objects

Classifying Seeds

Classifying Galaxies

Detecting Forged Signatures

Computer Readable Codes

The Universal Product Code

Fonts for Machine Readable Text

Reading Printed Text

The General OCR Problem

Scientific Images

Chromatography and DNA Sequencing: Biology

Stellar Image: Astronomy

Voyager Image Color Synthesis

Making Distance Measurements: Archaeology

Books:

1. *J. R. Parker, Practical Computer Vision Using C, John Wiley & Sons, 1993.*
2. *R. C Gonzalez and R. E. Woods, Digital Image Processing, Addison-Wesley Publishing Company, 1992.*

Code: BCS485 Cred Hrs: 3

Network Security

Principles and practices of Network Security, potential threats in connected environment and strategies to avoid, classical and contemporary cryptographic theories, cryptography as a tool to secure network communication, Odern SPN ciphers, block and stream ciphers. DES algorithm and public key cryptography. Linear cryptanalysis, key distribution and management, digital signatures and authentication.Data communication security protocols like IPSec, SSL etc. Secure voice communications, viruses and worms, denial of service attacks, firewalls. Digital Cash. Bio Authentication Algorithms.

Books:

1. ***Mark Rhodes-Ousley, Roberta Bragg, Keith Strassberg, Network Security: The Complete Reference, 1st Edition, McGraw Hill, 2003.***
2. ***Eric Maiwald, Network Security: A Beginner's Guide, 2nd Edition, McGraw Hill Osborne Media, 2003.***

Code: BCS486 Cred Hrs: 3

Modeling and Simulation

Introduction to OPNET: Introduction, Tool Environment, System Buttons, Tools, Online Documentation.

Introduction to Network Simulation:M/M/1 Queue Example, objectives, M/M/1 Queue Extensions.

Automatic Request Repeat (ARQ) Protocols: Objectives, Preparation, Stop and Wait, Go-Back-N, Selective Repeat, Conclusions.

Multiple Access Protocols: Objectives, Preparation, Aloha, CSMA, Ethernet, Token Ring, Conclusions.

Frame Relay: Objectives, Preparation, Network Model, Specify Probes, Prepare a simulation Set Object, Conclusions, extensions.

Fiber Distributed Data Interface: Objectives, Network Model, Specify Probes, Simulation, Execution and Result Analysis, Conclusions.

Job Service Disciplines: First-in-First-out, Priority Job Discipline, Preempt and Resume, Processor sharing, Shortest –job First discipline, Conclusions.

Books

1. *Modeling and Simulation Communication Networks: A hands on Approach Using OPNET, 1st Edition, Prentice Hall Inc, 1998.*
2. *Andrew S. Tanenbaum, Computer Networks, 3rd Edition, Prentice Hall, 1996.*

Code: BCS487 Cred Hrs: 3

Database Administration

Data administration objectives and functions. Data dictionary: Management uses and features. Developing a Data Dictionary System. Database security: Threats Analysis, Cryptographic controls. Database Integrity. Auditing of databases. Evaluation of Controls. Case histories.

Books:

1. *Craig S. Mullins, Database Administration: The Complete Guide to Practices and Procedures, 1st Edition, Addison Wesley Professional, 2002.*
2. *Jeffery A.Hoffer, Mary Prescott, Fred McFadden, Modern Database Management, 7th Edition, Prentice Hall, 2004.*

Code: BCS488 Cred Hrs:3

Telecommunication systems

Introduction to media, bandwidth and noise, twisted pair (UTP, STP), coaxial cables (types and specification), optical fibers (types), introduction to optical sources and detectors, microwave links, satellite communication and infrared links, switching, circuit and packet switching, introduction to mobile and cellular communication, block diagram and current trend.
Analog modulation schemes: AM, DSBSC, SSB, FM and PM; FDM and FDMA concepts; carrier frequency recovery and phase locked loop. Analog Mobile System (AMPS). Partial digital systems, PAM, PCM, DPCM, Delta Modulation. Frame synchronization. Telephone systems(TDM); Digital satellite systems(TDMA).Simple Digital systems: Binary modulation, QPSK, Binary FSK. Digital Mobile Systems (GSM, CDMA and GPRS). Satellite Mobile Systems. Simple network concepts, Telephone network.

Books:

1. *Annabel Z. Dodd, The Essential Guide to Telecommunications, 2nd Edition, Prentice Hall incorp, 1999.*
2. *William Stallings, Data and Computer Communications, 5th Edition, Prentice Hall, 1994.*
3. *Andrew S. Tanenbaum, Computer Networks, 2nd Edition, Prentice Hall Inc, 1995.*

Code: BCS489 Cred Hrs: 3

Multimedia Technologies

Introduction to multimedia programming, scope of multimedia programming, convention and trends, media used in current application (including digital video, audio, and graphics), system level issues of performance synchronization, storage and server schemes, dynamic Interactivity, hyperlinking, multimedia, device control, distributed media development and delivery, non-standard media and programming frame works, introduction to multi-media networks.

Books:

1. *Stephen M. Alessi, Stanley R. Trollip, Multimedia for Learning: Methods and Development, 3rd Edition, Allyn & Bacon, 2000.*
2. *Richard E. Mayer, Multimedia Learning, New Edition, Cambridge University Press, 2001.*