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Office of the
Deputy Director (Curriculum)

No. 5-4/HEC/CURR/COMP/2023/4394
February 16, 2023

SUBJECT: REVISED CURRICULUM - COMPUTING DISCIPLINES

Dear Sir / Madam,

Development and review of academic standards at tertiary level is one of the major functions of Higher Education Commission (HEC). HEC in collaboration with National Computing Education Accreditation Council (NCEAC) has developed/revised the curricula of following computing disciplines at undergraduate level;

1. BS in Computer Science
2. BS in Software Engineering
3. BS in Artificial Intelligence
4. BS in Data Science
5. BS in Cyber Security
6. BS in Bioinformatics
7. BS in Information Systems
8. BS in Multimedia and Gaming
9. BS in Information Technology
10. BS in Computer Engineering

In addition, a standardized scheme of studies for Associate Degree in Computing in also included in the document. The same is shared for guidance and implementation by all universities offering programs in the mentioned disciplines.

Encl: As above

HIDAYATULLAH KASI

Vice Chancellors / Rectors / Heads
All Public / Private Sector Universities / DAIs

Copy for information to:

i. ES to Chairman, Higher Education Commission, Islamabad
ii. ES to Executive Director, Higher Education Commission, Islamabad
iii. Chairperson National Computing Education Accreditation Council (NCEAC), Islamabad
iv. Advisor (Curriculum, Academics and NAHE), Higher Education Commission, Islamabad
v. DG (Attestation & Accreditation), Higher Education Commission, Islamabad
vi. DG (Quality Assurance Division), Higher Education Commission, Islamabad
vii. In-Charge HEC Regional Centers (Lahore, Peshawar, Karachi, Quetta)

CURRICULUM

OF

UNDERGRADUATE DEGREE PROGRAMS

COMPUTING DISCIPLINES

(Revised 2023)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

Contents

PREFACE

The curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village; new ideas and information are pouring in like a stream. It is, therefore, imperative to update the curricula of our degree programs regularly by introducing recent developments in the relevant fields of knowledge. In pursuance of this goal, the Higher Education Commission (HEC) is continually performing curricula revision in collaboration with universities. According to the decision of the special meeting of Vice-Chancellors Committee, curriculum of each subject must be reviewed after every 3 years.

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic program are required to undergo to achieve some specific objectives. It includes scheme of studies, objectives & learning outcomes, course contents, teaching methodologies and assessment/ evaluation. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

In compliance with the above provisions, the Curriculum Division of HECundertakes the revision of curricula regularly through respective National Curriculum Revision Committees (NCRCs) and Accreditation Councils that consist of eminent professors, researchers, and practitioners of the relevant fields from public and private sector universities, R&D organizations, councils, industry, and civil society by seeking nominations from their organizations. In this regard, HEC in collaboration with National Computing Education Accreditation Council (NCEAC) re-designed and combined all previous curricula of computing programs into a single document. It includes the curriculum of Computer Science and nine other sub-domains of computing.

In order to impart quality education, which is at par with indigenous needs and international standards, HEC-NCEAC has developed a unified framework/template using international guidelines made by ACM/IEEE and Seoul Accord. It is hoped that this document would serve the purpose of meeting our national, social and economic needs, as well as provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards.

Executive Director HEC

NCEAC Chairman's Message

Recent expansion of Higher Education sector in Pakistan and internationally has necessitated the focus on quality of computing education. The quality and competence of graduates and their relevance is critical for socio-economic uplift and manpower required to meet the needs of the country. HEC's National Computing Education Accreditation Council (NCEAC) is the Regulatory Body established by HEC to undertake multiple tasks to facilitate computing education in the country and devise steps to enhance its quality. The quality of computing programs is ensured through a comprehensive process that includes relevance of curricula, adaptation of international best practices, accreditation, trainings, and etc.

Recently, a roundtable conference was held in Islamabad to discuss the impediments in IT/Computer Science curriculum and bringing it at par with international standards and to meet the industry/ employer needs. The conference was held on July 26, 2022, at P Block Pak Secretariat, Islamabad under the convenorship of Honorable Mr. Ahsan Iqbal, Federal Minister for Planning, Development, and Special Initiatives, whereas Chairperson/Executive Director of Higher Education Commission, Dr Shaista Sohail was the co-chair/moderator of the event. Eminent IT and Computer Science professionals of local and international industry, academia and government sector participated in the roundtable conference. The conference discussed the need of a comprehensive curriculum for the computing on urgent basis. The meeting was informed that a group of NCEAC experts are already working to develop a state-of-art-the-computing curriculum model to cater the needs of both local and international markets.

NCEAC accelerated its efforts after the meeting to complete this task. This document presents the curriculum models for BS Computer Science and its nine sub-domains such as Software Engineering, Artificial Intelligence, Information Technology, Data Science, Bioinformatics, Cyber Security, Information Systems, Computer Engineering, and Gaming and Multimedia. The important aspect of these models is to incorporate the Outcome Based Education (OBE) concept for the first time into the computing curricula in Pakistan. The newly developed curricula for the above disciplines provide much more academic freedom and flexibility to the universities/DAIs to take advantage of their expertise to offer highly specialized degrees in sub-domains using electives courses stream.

I would like to thank the team of NCEAC experts and Mr Muhammad Raza Chohan Advisor (Curriculum, Academics and NAHE) HEC for their outstanding efforts to come up with an integrated curriculum for computing subjects. Special thanks are also due for Prof Dr Jamil Sawar and Prof Dr Jamil Ahmad for their efforts to complete this task. NCEAC acknowledges the support and efforts of computing professionals and academics for their contributions, especially NCEAC Secretariat and composers & editors of this document.

Prof Dr Syed Mansoor Sarwar
Chairman, NCEAC
January 2023

Executive Summary

Computing is a dynamic, flexible, and an integrated large domain of scientific and engineering knowledge, technologies, and R&D with enormous applications. However, it may be characterized as a nucleus of all activities including technical, academic, professional and development practices relating to computers. Accordingly, it involves development of technologies and techniques via hardware, software, and communication. Moreover, innovative, and limitless applications of computing pertain to designing and building of hardware and software systems for a variety of purposes. Additionally, it deals with the automatic processing, protection, management and structuring of a whole range of information in different formats. Computing is not just a single discipline but is a family of disciplines. There may be dozens if not hundreds around the world. However, among them, the following appear to have some distinction today:

1. Computer Science
2. Software Engineering
3. Information Technology
4. Bioinformatics
5. Artificial Intelligence
6. Data Science
7. Cyber Security
8. Information Systems
9. Computer Engineering
10. Gaming and Multimedia

After the COVID-19 Pandemic in particular, computing is reshaping in the way we live and work. In today's world, nearly everyone uses computers as part of everyday life. This field offers a variety of jobs with flexibility. Because of the global demand for the computing-skills based workforce, a huge number of students have been attracted to field in recent years. For nearly two decades, the Higher Education Commission (HEC), Pakistan has been making sustained efforts to uplift standards in computing education through NCEAC. The National Curriculum Revision Committee (NCRC) also played its significant role in this regard. Like other international bodies for the development of computing curricula, NCEAC and NCRC have also produced commendable results in Pakistan in this respect. Starting from the first formal curriculum in 2001 (erstwhile UGC), this journey continues to produce excellent results in this regard.

The phenomenal growth of the computing applications has created serious challenges for Government, HEC-NCEAC and universities to offer quality computing degree programs, so the graduates can compete at the international market. The overall progress of the computing discipline in terms of export and production of various local software products indicate that these challenges are being taken care of. In order to further enhance the quality and meet the international standards, the HEC-NCEAC revised computing curricula keeping in mind the ACM and Seoul Accord guidelines.

Though the development of curricula is a time-consuming task but highly experienced and qualified HEC-NCEAC team made this task possible within a few months. NCEAC also arranged a few meetings with IT industry to get feedback about their requirements and expectations.

This document also presents a comprehensive curriculum plan for the Associate Degree in Computing. The duration of the Associate Degree is two years with an option to upgrade it into a full-

fledged bachelor's degree program. Associate degree is offered to students who complete FA/FSc or equivalent qualification after 12 years of schooling. Details of curriculum are given later in this document. In addition, students of the BS programs will also be allowed to take an exit with Associate Degree after two years subject to fulfillment of all the requirements of the Associate degree.

1 Introduction

Computing (a nucleus of all activities including technical, academic, professional and development practices relating to computers) provides a wide range of choices on how an individual might focus his or her professional life. This document provides an overview of the different kinds of degree programs in Computing that are currently available and for which curriculum standards are now available. It is believed that this report may be an essential source for university faculty, administrators, students, parents and professionals who need to be aware of Computing as a broad based discipline that crosses the boundaries between science, engineering, and professional practice. In reality, computing consists of several disciplines. Various questions are naturally critical including: what are the different kinds of Computing degree programs or how are they similar and how are they different? The variety of degree programs in Computing presents prospective students, educators, and administrators with important choices where they may focus their efforts.

The following part of this section introduces the objectives of the report, the basic concept of Computing and a brief overview of Computer Science, Software Engineering, Information Technology and other disciplines. Further, the following sections of the report also provide a complete detail of the proposed curricula pertaining to Computer Science, Software Engineering, Artificial Intelligence, Information Technology and other disciplines regarding BS program. For each discipline, all details regarding the scheme of study, common course content with CLOs, and overall structure of the degree programs are presented in this document. Computing is a dynamic field and accordingly a good care has been taken to design a flexible structure that will maintain currency with the latest scientific and technological advancements in the field. Moreover, it seems that Computing is a discipline that incorporates scientific, engineering, and creative features. A reasonable emphasis has been given to formal scientific and engineering areas to enhance the level of formalization in the degree programs. Technology can play an important role in the implementation of Computing programs. As a result, all programs are structured on essential dimensions including scientific knowledge, technology, and design skills.

1.1 Objectives

Computing is one of the key factors driving the progress in 21st century — it will further transform the way we live, learn, work, and play. Advances in Computing and its technologies created new infrastructure for business, commerce, manufacturing, communication, scientific research, education, and social interaction. This expanding infrastructure provided us with new tools for communicating throughout the world and for acquiring knowledge and insight from information. It also provides a vehicle for economic growth. The following are the major objectives to considered while designing/developing new curricula.

1. Vigorous Computing education and research and development are essential for achieving our national aspirations of the 21st century. As we are advancing in the 21st century, the opportunities

for innovation in Computing are larger than they have ever been — and more important. The technical advances that led to today's information tools, such as electronic computers and the Internet, are accessible with continuously decreasing cost.

2. The nation is in need of significant efforts on education and research in Computing and communication systems. If the results are to be available when needed, we must act now to reinvigorate the long-term Computing education and research endeavor and to revitalize the computing infrastructure at university campus level. We need to ensure that advances in Computing work should benefit us and that the majority of Pakistanis have the education and training needed to prosper in a world that will increasingly depend on Computing. The benefits of these transformations caused by Computing for our national future are extraordinary. A networked society can reach out to all its citizens, can bring us closer together and address many societal issues.
3. The proposed plan of Computing curricula directly supports the education and preparation of our young people for careers in Computing research, and the training of workers who need to upgrade their skills to keep pace with a changing marketplace. Trained people are a major product of publicly supported research. These trained professionals are critical national human resource, and will create and develop new ideas, form a talent pool for existing business, and launch new companies.
4. Now as the current world is considered a global village due to the rapid flow of information from one place to another, the one who can share and access this information is considered a part of the global village. The astronomical growth in Computing compels the whole professional world to reorient their efforts to maximize utilization of Computing in their professional activities. This enables all the educational institutes, which are primarily responsible to create trained manpower, for devising programs that will lead to an optimum utilization of Computing in different spheres of life. There is a tremendous challenge to create well-equipped Computing professionals who have the ability and expertise to respond adequately to growing needs of the industry.
5. Realizing the high market demands and shortage of quality in Computing education at different levels and enhancement in existing Computing programs is proposed. This report is based upon horizontal and vertical growth in those disciplines of Computing whereas high demand is recent, and it is well estimated that this will grow universally for the years to come. Thus, it is high time for our universities to focus their resources together to seize a maximum share from this exponentially growing market.
6. The report conceptually and philosophically provides two-dimensional model of the overall Computing Educational Infrastructure. The concept nicely reflects national and international frontiers on Computing education for the upcoming future.
7. Our universities have quality human and technological resources and an excellent infrastructure. The report provides new horizons, strategies and challenges to transform the existing infrastructure into leading Computing institutions.

This document presents revised computing curricula which is to be known as 'the Computing Curricula 2023'. All previous curricula have been combined into a single document. Though a separate curriculum model is given for each sub domain of computing, but these individuals models are integrated by common courses. The main purpose of these efforts is to summarize and synthesize the current state of curriculum guidelines for academic programs that grant bachelor degrees in

computing as well as offer flexibility for the universities/DAIs while implementing these guidelines. The curriculum models for the following computing discipline are presented in this document.

1. Bachelor of Science in Computer Science
2. Bachelor of Science in Software Engineering
3. Bachelor of Science in Artificial Intelligence
4. Bachelor of Science in Data Science
5. Bachelor of Science in Cyber Security
6. Bachelor of Science in Bioinformatics
7. Bachelor of Science in Information Systems
8. Bachelor of Science in Multimedia and Gaming
9. Bachelor of Science in Information Technology
10. Bachelor of Science in Computer Engineering

2 Curricula Consideration

During the revision of the Computing Curricula two major guidelines have been considered (ACM and Seoul Accord). However, in some cases the main focus of these guidelines is mostly traditional Computer Science program.

2.1 Association of Computing Machinery (ACM) - Guidelines

Association of Computing Machinery (ACM), USA is the largest body in the world for computer scientists. Its membership is spread over the entire globe. It has a pool of highly reputed professionals which meet after a few years to assess the directions being taken by the computing discipline. In view of its assessment, it identifies knowledge areas and also their relative importance in the years to come. Thus, ACM shows the path to follow to the computing academia and professionals all over the world. Computing curricula are designed keeping in view following identified knowledge areas of ACM [ref # ACM 2013 curriculum report]. It has been tried to reasonably cover all knowledge areas without compromising the flexibility needed for a national model curriculum. The mapping of these key knowledge areas with the courses are given in table below.

- AL - Algorithms and Complexity
- AR - Architecture and Organization
- CN - Computational Science
- DS - Discrete Structures
- GV - Graphics and Visual Computing
- HCI - Human-Computer Interaction
- IAS - Information Assurance and Security
- IM - Information Management
- IS - Intelligent Systems
- NC - Networking and Communications
- OS - Operating Systems
- PBD - Platform-based Development
- PD - Parallel and Distributed Computing
- PL - Programming Languages

- SDF - Software Development Fundamentals
- SE - Software Engineering
- SF - Systems Fundamentals
- SP - Social Issues and Professional Issues

The following knowledge areas have been addressed with the major computing courses.

2.2 Knowledge Areas in ACM CS 2013 Curriculum

#	Knowledge Area	CS 2013		ACM 2013 Subjects Taught in Various Universities	NCEAC Revised 2023 Subjects in Core
		Tier-1	Tier-2		
1	AL-Algorithms and Complexity	19	9	Algorithms; Algorithms and Data Structures; Algorithm Design and Analysis	Data structures, Analysis of Algorithms, Theory of Automata
2	AR-Architecture and Organization	0	16	Intro to Computer Architecture; DLD; Computer Engineering	DLD, Computer Org & Assembly Language, Computer Architecture
3	CN-Computational Science	1	0	eScience; Modeling and Simulation; Computer Graphics	HCI & Computer Graphics; (Elective: Numerical Analysis)
4	DS-Discrete Structures	37	4	Discrete Mathematics; Mathematical Foundations of CS; Probability for CS; Discrete Structures 1; Discrete Str 2	Discrete Structures, Probability & Statistics
5	GV-Graphics and Visualization	2	1	Computer Graphics; Computer Graphics	HCI & Computer Graphics; (Elective: Computer Graphics)
6	HCI-Human-Computer Interaction	4	4	Human Computer Interaction	HCI & Computer Graphics
7	IAS-Information Assurance and Security	3	6	Computer Systems Security	Information Security; (Elective: Cyber Security)
8	IM-Information Management	1	9	Database Systems	Database Systems; Adv Database Management Sys
9	IS-Intelligent Systems	0	10	Artificial Intelligence Programming; Artificial Intelligence	Artificial Intelligence
10	NC-Networking and Communication	3	7	Introduction to Computer Networking; Computer Networks	Computer Networks

11	OS-Operating Systems	4	11	Operating Systems	Operating Systems
12	PBD-Platform-based Development	0	0		(Electives: Web Technology {ASP, Javascript}, Visual Prog {C#}, Mobile App Dev {React/Flutter/Kotlin/Swift})
13	PD-Parallel and Distributed Computing	5	10	Parallel Programming Principle and Practice;	Parallel & Distributed Computing
14	PL-Programming Languages	8	20	Introduction to Compilers; Compilers; Introduction to Programming; Programming Languages	Programming Fundamentals, OOP, Compiler Construction
15	SDF-Software Development Fundamentals	43	0	Java Programming I; Introduction to Program Design: Introduction to Programming; OOP	Programming Fundamental, Object Oriented Programming, Data Structures
16	SE-Software Engineering	6	22	Software Engineering	Software Engineering
17	SF-Systems Fundamentals	18	9	Computer Systems and Networks; Great Ideas in Computer Architecture; System Programming	DLD, Computer Networks, Computer Architecture
18	SP-Social Issues and Professional Practice	11	5	Ethics in Technology; Technology Consulting in the Community	Professional Practices
	Total Core Hours	**165**	**143**		
		308			

2.3 Outcome Based Education (OBE) System and Seoul Accord:

Keeping in view the latest transformation from knowledge-based education philosophy to Outcome based education (OBE) system, the OBE model based on Seoul Accord has also been considered. Computing programs prepare students to attain educational objectives by ensuring that students demonstrate achievement of the following outcomes (derived from Graduate Attributes define by Seoul Accord www.seoulaccord.org).

S#	Program Learning Outcomes (PLOs)	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 Team Work	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

3 BS Computing Curriculum Model

The combined structure of BS Degree Programs in Computing is proposed to meet the needs of students through theory and practical computing experience. The students are expected to learn theoretical and practical understanding of the respective field of Computing. The proposed structure is dynamic and provides basis for various options including Breadth-Based, Depth-Based, and Integrated Breadth & Depth- Based specializations. Students may choose a particular option, which is most appropriate to their planned future career.

The General structure of the BS degree in any discipline of Computing is given in the table below. The whole degree program structure is divided into different categories/areas. Some of the categories are common and shall be covered by all degree programs of the computing discipline, for example Computing Core, General Education, etc. The domain elective provides high degree of flexibility to the program to excel in one or two areas. For example any program would like to make specialty in the area of database or computer architecture where 7 courses (see category no. 5) can be offered to do so.

Table no. 3.1 Various Categories/Areas under Computing Discipline

C#	Category/Areas	Credit Hours	Courses	Remarks
1	Computing Core	46	14	Common to all computing programs
2	Domain Core	18	6	Related to the domain and must be different from one computing degree program to another.
3	Domain Elective	21	7	These courses are electives and would be very useful to provide in depth special knowledge under a specific domain. For example – under the Computer Science – one can take 7 courses from database or Artificial intelligence, etc.
4	Mathematics & Supporting Courses	12	4	Common to all computing degree programs.
5	Elective Supporting Courses	3	1	Common to all computing degree programs.
6	General Education Requirement	30	12	Common to all computing degree program and to be offered as per the HEC Guidelines, details can be found at HEC url. www.hec.gov.pk
	Totals	**130**	**44**	

3.1 Essential Requirements for the Computing Degree:

The following are the fundamental requirements to get admission and complete Computing degrees in universities/DAIs of Pakistan,

Eligibility Criteria, Duration of the Program and Award of Degree:

- Minimum 50% marks in Intermediate/12 years schooling/A- Level (HSSC) or Equivalent with Mathematics are required for admission in all BS Computing Programs other than BS Computing Engineering.
  **Equivalency certificate by IBCC will be required in case of education from some other country or system.*
- Minimum 60% marks in Intermediate/12 years schooling/A- Level (HSSC) or Equivalent with Mathematics are required for admission in BS Computer Engineering Program.
- The students who have not studied Mathematics at intermediate level have to pass deficiency courses of Mathematics (06 credits) in first two semesters.
- At minimum 130 credit hours are required for award of BS degrees in any computing discipline mentioned in this document.
- The minimum duration for completion of BS Computing degrees is four years. The HEC allows maximum period of seven years to complete BS degree requirements.
- A minimum 2.0 CGPA (Cumulative Grade Point Average) on a scale of 4.0 is required for award of BS Computing Degree.
- The students after successful completion of 04 semesters in BS Computing Programs may exit with Associate Degree in Computing subject to completion of all requirements for the award of associate degree, i.e., Credit Hours, CGPA, and compulsory courses.

3.2 General Layout and Courses:

In order to facilitate universities/DAIs who offer computing degree programs, this section present the general layout and courses details under various categories as mentioned above. There are ten different degree programs which can be offered under the computing discipline (see section 1). In order to make it flexible and easy for institutes to execute Computing degree program with desired quality, a common layout has been designed to make a similar layout and plan for each degree offered under the computing domain. The table below shows courses under different categories. Some of the categories are shown with generic course title such as Domain Core 1, 2 and so on. Actual titles and other details are given in the later sections of this document. This section also provides guidelines about the code scheme of courses.

3.3 Coding Scheme of Courses:

The code of the courses can be designed by the university, but the following guidelines may be followed:

- Coding Scheme is based on the following principles:
  - Letter Code consists of two to four characters (three is preferred) to represents the title of the degree
    - Such as CSC for Computer Science, SE for Software Engineering, DSC , Data Sciences
    - MTH – Mathematics, PHY – Physics, etc.
  - Numerical code consists of three digits

- 1st digit represents the level of difficulty
- 2nd digit represents the area/specialization
- 3rd digit represents the sequence in the area/specialization
- For example: 101 (1 - difficult level, 0 normally fundamental area, 1 first course in the area)

Other examples

- For example - a course code CSC332
  - Level of Difficulty – 3 (could be offered in year 3), 3 – the course belongs to Databases, and 2 - this is 2nd course in the area of databases.
- For example a course code CSC212
  - Level of Difficulty – 2 (could be offered in year 2), 1 – the course belongs to Programming, and 2 - this is 2nd course in the area of programming.

However, it is up to the university where they can use different type and style.

Table 3.2 : The Overall Degree Plan with Generic layout and Courses

#	Sem #	Code	Pre-Reqs	Course Title	Dom	CrHr
				Computing Core (46/130) 14 Courses (common to all computing programs)		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses – vary from program to program		
15	--	CSxxx		Domain Core 1	Domain Core	3 (2-3)
16	--	CSxxx		Domain Core 2	Domain Core	3 (2-3)
17	--	CSxxx		Domain Core 3	Domain Core	3 (2-3)
18	--	CSxxx		Domain Core 4	Domain Core	3 (2-3)
19	--	CSxxx		Domain Core 5	Domain Core	3 (2-3)
20	--	CSxxx		Domain Core 6	Domain Core	3 (2-3)
	(code from Domain such as CS, SE, AI etc.			**Domain Elective (21/130) 7 Courses – specific to the degree program**		
21	--	DOMxxx		Domain Elective 1	Domain Elective	3 (2-3)
22	--	DOMxxx		Domain Elective 2	Domain Elective	3 (2-3)
23	--	DOMxxx		Domain Elective 3	Domain Elective	3 (2-3)
24	--	DOMxxx		Domain Elective 4	Domain Elective	3 (2-3)
25	--	DOMxxx		Domain Elective 5	Domain Elective	3 (2-3)
26	--	DOMxxx		Domain Elective 6	Domain Elective	3 (2-3)
27	--	DOMxxx		Domain Elective 7	Domain Elective	3 (2-3)
				Mathematics Supporting Courses Common to all degree programs (12/130) 4 Courses		
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	CPS	Technical & Business Writing	EW	3 (3-0)
				Elective Supporting Courses (3/130) 1 Course		
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
				General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses		
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)

34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

The following pages present each degree program along with its introduction and details of courses.

4 Computing Degree Programs

As mentioned before that there are ten different degree programs which can be offered under the Computing discipline. All these programs are presented in the following sections.

4.1 BS Computer Science

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 [ref WordNet Princeton definition].

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 the principles and practices of engineering. The program aims to train students in all aspects of software life cycle from specification through analysis and design to testing, maintenance and evaluation of software product.

Computer Science spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas. The overall scope of Computer Science may be viewed into the following three categories:

- To develop effective ways to solve computing problems. For example, Computer Science develops the best possible ways to store information in databases, send data over networks, and display complex images. The theoretical background offered by Computer Science allows determining the best performance possible, and their study of algorithms. It enables to develop new problem-solving approaches that provide better performance.
- It devises new ways to use computers intelligently and effectively. Progress in the areas of networking, database, and human-computer-interface came together as a result of the world-wide-web, which changed the entire world. Now, researchers are working to make robots that are practical aides and demonstrate intelligence, databases that create new knowledge and, in general, use computers to do new things.
- It deals with the design and implementation of software systems. Computer Science provides training and skills for the successful implementation of software systems that solve challenging

programming jobs. Computer Science spans the range from theory to models, design and programming. Computer Science offers a comprehensive foundation that permits graduates to adapt to new technologies and new ideas.

4.1.1 Curriculum Model for Bachelor of Science in Computer Science

The generic structure for computing degree program given before is mapped with the BSCS program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSCS Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Theory of Automata	Domain Core	3 (3-0)
16	4	CS2xx	DB	Advance Database Management Systems	Domain Core	3 (2-3)
17	5	CS3xx		HCI & Computer Graphics	Domain Core	3 (2-3)
18	5	CS3xx	COAL	Computer Architecture	Domain Core	3 (2-3)
19	6	CS3xx	TA	Compiler Construction	Domain Core	3 (2-3)
20	6	CS3xx	OS	Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Web Technologies	Domain Elective	3 (2-3)
22	5	CS3xx		Mobile Application Development 1	Domain Elective	3 (2-3)
23	6	CS3xx	OOP	Advanced Programming (Old Name: Visual Programming)	Domain Elective	3 (2-3)
24	6	CS3xx		Numerical Analysis	Domain Elective	3 (2-3)
25	6	CS3xx	WT	Web Engineering	Domain Elective	3 (2-3)
26	6	CS3xx	IS	Cyber Security	Domain Elective	3 (2-3)
27	7	CS4xx		Software Testing & Quality Assurance	Domain Elective	3 (2-3)
.				Mobile Application Development 2	Domain Elective	3 (2-3)
.				Cloud Computing	Domain Elective	3 (2-3)
.				Computer Graphics	Domain Elective	3 (2-3)

.				Object Oriented Analysis & Design	Domain Elective	3 (2-3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.1.2 Suggested Semester/Study Plan for BSCS

Sem 1 + Sem 3 + Sem 5 + Sem 7 = **Theory 54 hours + Lab 42 hours**
Sem 2 + Sem 4 + Sem 6 + Sem 8 = **Theory 46 hours + Lab 36 hours + Project Lab 12 hours**

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Theory of Automata)	Domain Core	3 (3-0)
19	CS2xx		Domain Core 2 (Advance Database Management Systems)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics *Should be offered in 3rd Sem for CE)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)

24	CS3xx		Domain Core 3 (HCI & Computer Graphics)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Computer Architecture)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1 (Example: Web Technologies)	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2 (Example: Mobile Application Development 1)	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Compiler Construction)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3 (Example: Advanced Programming – Visual Prog)	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4 (Example: Numerical Analysis)	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5 (Example: Web Engineering)	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6 (Example: Cyber Security)	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7 (Example: Software Testing & Quality Assurance)	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.2 Bachelor of Science Software Engineering - BSSE

Software Engineering is the discipline of developing and maintaining software systems that behave reliably and efficiently, and are affordable to develop and maintain. However, more recently it has evolved in response to the increased importance of software in safety-critical applications and to the growing impact of large and expensive software systems in a wide range of situations. The following describes an overview of Software Engineering.

- To provide software development practices requires more than just the under lying principles of computer science; it offers the rigor that the engineering disciplines bring to the reliability and trust worthiness of the artefacts.
- Software Engineering is different in character from other engineering disciplines, due to both the in tangible nature of software and to the discontinuous nature of software operation.
- It seeks to integrate the science of Computer Science with the engineering principles developed for tangible and physical phenomena.

Software plays a central and underpinning role in almost all aspects of daily life: communications, government, manufacturing, banking and finance, education, transportation, entertainment, medicine, agriculture, and law. The number, size, and application domains of computer programs have grown dramatically; as a result, huge sums are being spent on software development. Most people's lives and livelihoods depend on this development's effectiveness. Software products help us to be more efficient and productive. They provide information, make us more effective problem solvers, and provide us with safer, flexible, and less confining work, entertainment, and recreation environments.

Software Engineering 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 the principles and practices of engineering. The department aims to train students in all aspects of software life cycle from specification through analysis and design to testing, maintenance and evolution of software product.

4.2.1 Curriculum Model for BS Software Engineering

The generic structure for computing degree program given before is mapped with the BSSE program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSSE Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Software Design & Architecture	Domain Core	3 (3-0)
16	4	CS2xx		Software Construction & Development	Domain Core	3 (2-3)
17	5	CS3xx		Software Project Management	Domain Core	3 (2-3)
18	5	CS3xx		Software Quality Engineering	Domain Core	3 (2-3)
19	6	CS3xx		Software Requirement Engineering	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Software Verification and Validation (Testing & QA)	Domain Elective	3 (2-3)
22	5	CS3xx		Object Oriented Analysis & Design	Domain Elective	3 (2-3)
23	6	CS3xx		Computer Architecture	Domain Elective	3 (2-3)
24	6	CS3xx		Theory of Automata	Domain Elective	3 (3-0)
25	6	CS3xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
26	6	CS3xx		Web Technologies	Domain Elective	3 (2-3)
27	7	CS4xx		Advanced Database Management	Domain Elective	3 (3-0)
.				Web Engineering	Domain Elective	3 (2-3)
.				Data Science	Domain Elective	3 (2-3)
.				Software Re-Engineering	Domain Elective	3 (2-3)
.				Mobile Application Development 1	Domain Elective	3 (2-3)
				Mathematics & Supporting Courses (12/130) 4 Courses		
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
				Elective Supporting Courses (3/130) 1 Course		
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
				General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses		
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.2.2 Suggested Semester/Study Plan for BSSE

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Software Design & Architecture)	Domain Core	3 (3-0)
19	CS2xx		Domain Core 2 (Software Construction & Development)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Software Quality Engineering)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Software Requirement Engineering)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Software Project Management)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.3 Bachelor of Science in Artificial Intelligence - BSAI

The BS (AI) program gives the students an in-depth knowledge they need to transform large and complex scenarios into actionable decisions. The program and its curriculum focus on how complex inputs — such as knowledge, vision, language and huge databases — can be used to make decisions to enhance human capabilities. The curriculum of the BS (AI) program includes coursework in computing, mathematics, automated reasoning, statistics, computational modeling, introduction to classical artificial intelligence languages and case studies, knowledge representation and reasoning, artificial neural networks, machine learning, natural language processing, vision and symbolic computation. The program also encourages students to take courses in ethics and social responsibility, with the opportunity to participate in long term projects in which artificial intelligence can be applied to solve problems that can change the world for the better — in areas like agriculture, defense, healthcare, governance, transportation, e-commerce, finance and education.

4.3.1 Curriculum Model for BS in Artificial Intelligence

The generic structure for computing degree program given before is mapped with the BSAI program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Electives	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSAI Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Programming for AI	Domain Core	3 (2-3)

16	4	CS2xx		Machine Learning	Domain Core	3 (2-3)
17	5	CS3xx		Artificial Neural Networks & Deep Learning	Domain Core	3 (2-3)
18	5	CS3xx		Knowledge Representation & Reasoning	Domain Core	3 (2-3)
19	6	CS3xx		Computer Vision	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
Domain Elective (21/130) 7 Courses						
21	5	CS3xx		Natural Language Processing	Domain Elective	3 (2-3)
22	5	CS3xx		Speech Processing	Domain Elective	3 (2-3)
23	6	CS3xx		Data Mining	Domain Elective	3 (2-3)
24	6	CS3xx		Advanced Statistics	Domain Elective	3 (2-3)
25	6	CS3xx		Reinforcement Learning	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (3-0)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Fuzzy Systems	Domain Elective	3 (2-3)
.				Swarm Intelligence	Domain Elective	3 (2-3)
.				Agent Based Modeling	Domain Elective	3 (2-3)
.				Knowledge Based Systems	Domain Elective	3 (2-3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.3.2 Suggested Semester/Study Plan for BSAI

#	Code	Pre-Reqs	Course Title	Domain	Cr Hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)

				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Programming for AI)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Machine Learning)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Artificial Neural Networks & Deep Learning)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Knowledge Representation & Reasoning)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Computer Vision)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.4 Bachelor of Science in Data Science - BSDS

BS (Data Science) has a dual emphasis on basic principles of statistics and computer science, with foundational training in statistical and mathematical aspects of data analysis. This program develops foundation on broad computer science principles, including algorithms, data structures, data management and machine learning. This program will prepare graduates for a career in data analysis, combining foundational statistical concepts with computational principles from computer science.

4.4.1 Curriculum Model for BS in Data Science

The generic structure for computing degree program given before is mapped with the BSDS program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSDS Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Introduction to Data Science	Domain Core	3 (2-3)
16	4	CS2xx		Advanced Statistics	Domain Core	3 (2-3)
17	5	CS3xx		Data Mining	Domain Core	3 (2-3)
18	5	CS3xx		Data Visualization	Domain Core	3 (2-3)
19	6	CS3xx		Data Warehousing & Business Intelligence	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Advanced Database Management Systems	Domain Elective	3 (2-3)
22	5	CS3xx		Big Data Analytics	Domain Elective	3 (2-3)

23	6	CS3xx		Machine Learning	Domain Elective	3 (2-3)
24	6	CS3xx		Artificial Neural Networks & Deep Learning	Domain Elective	3 (2-3)
25	6	CS3xx		Business Process Analysis	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2-3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Platforms & Architectures for Data Science	Domain Elective	3 (2-3)
.				Text Mining	Domain Elective	3 (2-3)
.				Topics in Data Science	Domain Elective	3 (2-3)
.				Speech Processing	Domain Elective	3 (2-3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.4.2 Suggested– Semester/Study Plan for BSDS

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Introduction to Data Science)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Advanced Statistics)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)

				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Data Mining)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Data Visualization)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Data Warehousing & Business Intelligence)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.5 Bachelor of Science in Cyber Security – BSCySec:

The BS (CySec) program intends to produce skilled professionals to understand the processes that impact information security, safeguarding information assets, collection and preservation of digital evidences, analysis of data, and identification and fixing of security vulnerabilities. The program will equip students with the fundamental knowledge of computer science that forms the technical foundation of the field, with an essential focus on experiential learning through laboratory exercises in the security courses. This degree is a state-of-the-art course with a perfect blend of Cyber Security that is designed to set the graduates up for immediate industry success by combining and leveraging today's cutting-edge technology with real-world scenarios.

4.5.1 Curriculum Model for BS in Cyber Security

The generic structure for computing degree program given before is mapped with the BSCySec program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSCySec Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Cyber Security	Domain Core	3 (2-3)
16	4	CS2xx		Information Assurance	Domain Core	3 (2-3)
17	5	CS3xx		Network Security	Domain Core	3 (2-3)
18	5	CS3xx		Secure Software Design and Development	Domain Core	3 (2-3)
19	6	CS3xx		Digital Forensics	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Vulnerability Assessment & Reverse Engineering	Domain Elective	3 (2-3)

22	5	CS3xx		Basic Electronics	Domain Elective	3 (2-3)
23	6	CS3xx		Hardware Security	Domain Elective	3 (2-3)
24	6	CS3xx		Malware Analysis	Domain Elective	3 (2-3)
25	6	CS3xx		Wireless and Mobile Security	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (3-0)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Penetration Testing	Domain Elective	3 (2-3)
.				Computer Architecture	Domain Elective	3 (2-3)
.				Advanced Digital Logic Design	Domain Elective	3 (2-3)
.				Embedded Systems	Domain Elective	3 (2-3)
.				Cyber Law & Cyber Crime (Cyber Warfare)	Domain Elective	3 (2-3)
.				Control System Security	Domain Elective	3 (2-3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.5.2 Suggested Semester/Study Plan for BSCySec

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Cyber Security)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Information Assurance)	Domain Core	3 (2-3)

20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Network Security)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Secure Software Design and Development)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Digital Forensics)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.6 Bachelor of Science in Bioinformatics - BSBI

4.6.1 Curriculum Model for BS in Bioinformatic

The generic structure for computing degree program given before is mapped with the BSBI program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSBI Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Basic General Chemistry	Domain Core	3 (2-3)
16	4	CS2xx		Basic Biology & Cell Biology	Domain Core	3 (2-3)
17	5	CS3xx		Evolutionary Biology	Domain Core	3 (2-3)
18	5	CS3xx		Intro to Bioinformatics & Computational Biology	Domain Core	3 (2-3)
19	6	CS3xx		Fundamentals of Genetics	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Bioinformatics & Scientific Computing	Domain Elective	3 (2-3)
22	5	CS3xx		Ethical & Legal Issues in Bioinformatics	Domain Elective	3 (2-3)
23	6	CS3xx		Introduction to Biotechnology	Domain Elective	3 (2-3)
24	6	CS3xx		Computer Aided Drug Designing	Domain Elective	3 (2-3)
25	6	CS3xx		Nano Technology	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2-3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Bioelectronics and Biosensors	Domain Elective	3 (2-3)
.				Bacterial Genetics	Domain Elective	3 (2-3)
.				Genomics	Domain Elective	3 (2-3)
.				Microbiology	Domain Elective	3 (2-3)
				Mathematics & Supporting Courses (12/130) 4 Courses		
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)

31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.6.2 Suggested Semester/Study Plan for BSBI

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Basic General Chemistry)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Basic Biology & Cell Biology)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Evolutionary Biology)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Intro to Bioinformatics & Computational Biology)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Fundamentals of Genetics)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)

32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.7 Bachelor of Science in Information Systems - BSIS

4.7.1 Curriculum Model for BS in Information System

The generic structure for computing degree program given before is mapped with the BSIS program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSIS Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		System Analysis	Domain Core	3 (3-0)
16	4	CS2xx		Analysis of Information Systems	Domain Core	3 (2-3)
17	5	CS3xx		Enterprise Resource Planning Systems	Domain Core	3 (2-3)
18	5	CS3xx		Management of Information Systems	Domain Core	3 (2-3)
19	6	CS3xx		Project Management	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Contract Management	Domain Elective	3 (2-3)
22	5	CS3xx		Service and Operation Management	Domain Elective	3 (2-3)
23	6	CS3xx		Software Requirement Engineering	Domain Elective	3 (2-3)
24	6	CS3xx		Web Technologies	Domain Elective	3 (2-3)
25	6	CS3xx		Cloud Computing	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2-3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Information System Theory	Domain Elective	3 (2-3)
.				Information System Security	Domain Elective	3 (2-3)
.				Web Engineering	Domain Elective	3 (2-3)
.				Cyber Security	Domain Elective	3 (2-3)
				Mathematics & Supporting Courses (12/130) 4 Courses		
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)

29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.7.2 Suggested Semester/Study Plan BSIS

#	Code	Pre-Reqs	Course Title	Domain	Cr Hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (System Analysis)	Domain Core	3 (3-0)
19	CS2xx		Domain Core 2 (Analysis of Information Systems)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Enterprise Resource Planning Systems)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Management of Information Systems)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Project Management)	Domain Core	3 (2-3)

30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.8 Bachelor of Science in Multimedia & Gaming - BSMG

4.8.1 Curriculum Model for BS in Multimedia and Gaming

The generic structure for computing degree program given before is mapped with the BSMG program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSMG Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Mobile Multimedia	Domain Core	3 (2-3)
16	4	CS2xx		Game Design and Development	Domain Core	3 (2-3)
17	5	CS3xx		Interactive Games and Audio	Domain Core	3 (2-3)
18	5	CS3xx		Game Programming	Domain Core	3 (2-3)
19	6	CS3xx		Video Production Techniques	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Art for Games	Domain Elective	3 (2-3)
22	5	CS3xx		Programming for 3D & Web 3D Apps	Domain Elective	3 (2-3)
23	6	CS3xx		Web Applications and Services	Domain Elective	3 (2-3)
24	6	CS3xx		Computer Graphics	Domain Elective	3 (2-3)
25	6	CS3xx		Video Games & Creative Writing	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2-3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Game Project Management	Domain Elective	3 (2-3)
.				Mobile Games & Entertainment	Domain Elective	3 (2-3)
.				Multicore & GPU Programming	Domain Elective	3 (2-3)
.				Foreign Languages (one or two languages)	Domain Elective	3 (2-3)

Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.8.2 Suggested Semester/Study Plan for BSMG

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Mobile Multimedia)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Game Design and Development)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (Interactive Games and Audio)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Game Programming)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**

			Semester 6		
29	CS3xx		Domain Core 5 (Video Production Techniques)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.9 Bachelor of Science in Information Technology - BSIT

4.9.1 Curriculum Model for BS in Information Technology

The generic structure for computing degree program given before is mapped with the BSIT program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSIT Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Web Technologies	Domain Core	3 (2-3)
16	4	CS2xx		Cyber Security	Domain Core	3 (2-3)
17	5	CS3xx		DB Administration & Management	Domain Core	3 (2-3)
18	5	CS3xx		System & Network Administration	Domain Core	3 (2-3)
19	6	CS3xx		Information Technology Infrastructure	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Virtual Systems & Services	Domain Elective	3 (2-3)
22	5	CS3xx		Computer Architecture	Domain Elective	3 (2-3)
23	6	CS3xx		Network Security	Domain Elective	3 (2-3)
24	6	CS3xx		Enterprise Systems	Domain Elective	3 (2-3)
25	6	CS3xx		Web Engineering	Domain Elective	3 (2-3)
26	6	CS3xx		Theory of Automata	Domain Elective	3 (2-3)
27	7	CS4xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
.				Software Project Management	Domain Elective	3 (2-3)
.				Cloud Computing	Domain Elective	3 (2-3)
.				Software Requirement Engineering	Domain Elective	3 (2-3)
.				Mobile Application Development 1	Domain Elective	3 (2-3)

Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.9.2 Suggested Semester/Study Plan for BSIT

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Web Technologies)	Domain Core	3 (2-3)
19	CS2xx		Domain Core 2 (Cyber Security)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (13-12)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)
24	CS3xx		Domain Core 3 (DB Administration & Management)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (System & Network Administration)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**

			Semester 6		
29	CS3xx		Domain Core 5 (Information Technology Infrastructure)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

4.10 Bachelor of Science in Computer Engineering – BSCE

BS in Computer Engineering provides detailed concept about the hardware of the computer system. Students of this program get firm knowledge about the system which they can use for developing outstanding Hardware, Firmware and Software. The following table shows the generic model along with different components of the curriculum model. This generic model is mapped to appropriate courses in the following sections.

4.10.1 Curriculum Model for BS in Computer Engineering

The generic structure for computing degree program given before is mapped with the BSCE program in the following tables.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	46	14
Domain Core	18	6
Domain Elective	21	7
Mathematics & Supporting Courses	12	4
Elective Supporting Courses	3	1
General Education Requirement	30	12
Totals	**130**	**44**

Mapping of BSCE Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (46/130) 14 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	3	CS2xx		Software Engineering	Core	3 (3-0)
10	4	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
11	5	CS3xx		Operating Systems	Core	3 (2-3)
12	7	CS4xx	DS	Analysis of Algorithms	Core	3 (3-0)
13	7	CS4xx		Final Year Project - I	Core	2 (0-6)
14	8	CS4xx	FYP-I	Final Year Project - II	Core	4 (0-12)
				Domain Core (18/130) 6 Courses		
15	4	CS2xx		Linear Circuit Analysis	Domain Core	3 (3-0)
16	4	CS2xx		Electrical Network Analysis	Domain Core	3 (2-3)
17	5	CS3xx		Electronic Devices & Circuits	Domain Core	3 (2-3)
18	5	CS3xx		Computer Architecture	Domain Core	3 (2-3)
19	6	CS3xx		Signals & Systems	Domain Core	3 (2-3)
20	6	CS3xx		Parallel & Distributed Computing	Domain Core	3 (2-3)
				Domain Elective (21/130) 7 Courses		
21	5	CS3xx		Parallel Computer Architectures	Domain Elective	3 (2-3)
22	5	CS3xx		Digital System Design	Domain Elective	3 (2-3)
23	6	CS3xx		Computer Interfacing	Domain Elective	3 (2-3)

24	6	CS3xx		Control Engineering	Domain Elective	3 (3-0)
25	6	CS3xx		Theory of Automata	Domain Elective	3 (3-0)
26	6	CS3xx		HCI & Computer Graphics	Domain Elective	3 (2-3)
27	7	CS4xx		Digital Signal Processing	Domain Elective	3 (2-3)
.				Embedded Systems	Domain Elective	3 (2-3)
.				Artificial Neural Networks & Deep Learning	Domain Elective	3 (2-3)
.				Digital Image Processing	Domain Elective	3 (2-3)
.					Domain Elective	3 (2-3)
Mathematics & Supporting Courses (12/130) 4 Courses						
28	2	MT1xx	CAG	Multivariable Calculus	Maths	3 (3-0)
29	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
30	3	MT2xx		Probability & Statistics	Maths	3 (3-0)
31	7	EW4xx	ECC	Technical & Business Writing	EW	3 (3-0)
Elective Supporting Courses (3/130) 1 Course						
32	7	SS1xx		Social Science (Example: Introduction to Marketing)	SS	3 (3-0)
.		SS1xx		Social Science (Example: Financial Accounting)	SS	3 (3-0)
General Education Requirement as per HEC UG Education Policy (30/130) 12 Courses						
33	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
34	1	GE1xx		Functional English	GER	3 (3-0)
35	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
36	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
37	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
38	4	GE2xx		Islamic Studies	GER	2 (2-0)
39	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
40	4	GE2xx		Social Sciences (Example: Introduction to Management)	GER	2 (2-0)
41	4	GE2xx		Natural Sciences (Applied Physics)	GER	3 (2-3)
42	8	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
43	8	GE4xx		Civics and Community Engagement	GER	2 (2-0)
44	7	GE4xx		Entrepreneurship	GER	2 (2-0)

4.10.2 Suggested Semester/Study Plan for BSCE

#	Code	Pre-Reqs	Course Title	Domain	Cr hr (Cont Hr)
			Semester 1		
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
			Semester 2		
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Multivariable Calculus	Maths	3 (3-0)
10	MT1xx		Linear Algebra	Maths	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 3		
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	MT2xx		Probability & Statistics	Maths	3 (3-0)
				Total Cr Hrs	**19 (15-12)**
			Semester 4		
17	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
18	CS2xx		Domain Core 1 (Linear Circuit Analysis)	Domain Core	3 (3-0)
19	CS2xx		Domain Core 2 (Electrical Network Analysis)	Domain Core	3 (2-3)
20	GE2xx		Natural Science (Applied Physics)	GER	3 (2-3)
21	GE1xx		Expository Writing	GER	3 (3-0)
22	GE2xx		Islamic Studies	GER	2 (2-0)
				Total Cr Hrs	**17 (14-9)**
			Semester 5		
23	CS3xx		Operating Systems	Core	3 (2-3)

24	CS3xx		Domain Core 3 (Electronic Devices & Circuits)	Domain Core	3 (2-3)
25	CS3xx		Domain Core 4 (Computer Architecture)	Domain Core	3 (2-3)
26	CS3xx		Domain Elective 1	Domain Elective	3 (2-3)
27	CS3xx		Domain Elective 2	Domain Elective	3 (2-3)
28	GE2xx		Social Science (Example: Introduction to Management)	GER	2 (2-0)
				Total Cr Hrs	**17 (12-15)**
			Semester 6		
29	CS3xx		Domain Core 5 (Signals & Systems)	Domain Core	3 (2-3)
30	CS3xx		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3 (2-3)
31	CS3xx		Domain Elective 3	Domain Elective	3 (2-3)
32	CS3xx		Domain Elective 4	Domain Elective	3 (2-3)
33	CS3xx		Domain Elective 5	Domain Elective	3 (2-3)
34	CS3xx		Domain Elective 6	Domain Elective	3 (2-3)
				Total Cr Hrs	**18 (12-18)**
			Semester 7		
35	CS4xx		Final Year Project - I	Core	2 (0-6)
36	CS4xx		Analysis of Algorithms	Core	3 (3-0)
37	CS4xx		Domain Elective 7	Domain Elective	3 (2-3)
38	SS1xx		Elective Supporting Course (Example: Introduction to Marketing)	SS	3 (3-0)
39	EN4xx		Technical & Business Writing	EN	3 (3-0)
40	GE4xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**16 (13-9)**
			Semester 8		
41	CS4xx		Final Year Project - II	Core	4 (0-12)
42	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
43	GE4xx		Arts & Humanities (Professional Practices)	GER	2 (2-0)
44	GE4xx		Civics and Community Engagement	GER	2 (2-0)
				Total Cr Hrs	**10 (6-12)**

5 Associate Degree in Computing

Associate Degree (AD) Computing program is a two years degree which covers important aspect of the computing discipline. The duration of the Associate Degree is two years with an option to upgrade it to a full-fledged bachelor's degree program. Important features of the AD programs are as follows;

1. Associate Degree Computing comprises of 04 semesters / 02 years duration. AD Computing may only be offered under semester system.
2. Semester duration is 18 weeks, including two weeks for examinations and results
3. The minimum credits for award of Associate Degree Computing is 72 Credit Hours.
4. Normal load per semester will be five to six courses and maximum up to 8 courses under special circumstances as per the university/DAI rules and regulations.
5. Courses will be described through Credit Hours (CrHr) system.
6. 1 (one) Theory CrHr is equivalent to 1 (one) contact hour per week in a normal semester of 15/16 weeks teaching so a 3 CrHr course means 45 contact hours for the whole semester.
7. 1 Lab CrHr is equivalent to 3 contact hours per week for 15/16 weeks
8. Summer/Winter semester of shorter can also be offered (if required), however, Summer/winter semester is mainly offered to cover deficiency courses.

5.1 Admission Requirement/Eligibility Criteria for AD Computing and Further Pathways

- Minimum 50% marks in Intermediate/12 years schooling/A- Level (HSSC) or Equivalent with Mathematics are required for admission in Associate Degree Computing.
  **Equivalency certificate by IBCC will be required in case of education from some other country or system.*
- The students who have not studied Mathematics at intermediate level have to pass deficiency courses of Mathematics (06 credits) in first two semesters.
- A minimum 2.0 CGPA (Cumulative Grade Point Average) on a scale of 4.0 is required for award of AD Computing degree.
- The candidates with AD Computing Degrees are eligible for admission in 5th Semester of BS Computing Programs. Such students shall complete the deficiency courses of General Education (if any) during 5th to 8th Semester.
- The candidates who acquired ADP Computing Degrees prior to the admission criteria (as stated above) are also eligible for admission in 5th Semester of BS Computing Programs. Such students shall complete the deficiency courses of General Education (if any) during 5th to 8th Semester.

5.2 Degree Equivalency

The Associate Degree is equivalent to 14 years of schooling – level 05 qualification as per National Qualifications Framework of Pakistan.

5.3 Title of Degree

The Nomenclature of the Associate Degree 'Title' may be written on degree as "Associate Degree in Computing".

5.4 Grading System

Grading of AD Computing shall be same as of the four years bachelor degree programs.

5.5 Curriculum Model for AD in Computer Science

Students will be required to complete the following courses to obtain Associate Degree CS.

Generic Structure for Computing Disciplines:

Areas	Credit Hours	Courses
Computing Core	34	10
Elective	14	5
Mathematics & Supporting Courses	3	1
General Education Requirement	21	8
Totals	**72**	**24**

Mapping of ADCS Program on the Generic Structure:

#	Sem #	Code	Pre-Reqs	Course Title	Dom	Cr Hr
				Computing Core (34/72) 10 Courses		
1	1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	2	CS1xx	PF	Object Oriented Programming	Core	4 (3-3)
3	2	CS1xx		Database Systems	Core	4 (3-3)
4	2	CS1xx		Digital Logic Design	Core	3 (2-3)
5	3	CS2xx	OOP	Data Structures	Core	4 (3-3)
6	3	CS2xx		Information Security	Core	3 (2-3)
7	3	CS2xx		Artificial Intelligence	Core	3 (2-3)
8	3	CS2xx		Computer Networks	Core	3 (2-3)
9	5	CS2xx	DLD	Computer Organization & Assembly Language	Core	3 (2-3)
10	4	CS2xx		Software Engineering	Core	3 (3-0)
				Electives (14/72) 5 Courses (Universities can add more Lab Courses)		
11				Advanced Database Lab	Elective	2 (0-6)
12				Web Technologies Lab	Elective	3 (1-6)
13				Mobile Application Development Lab	Elective	3 (1-6)
14				Advanced Programming Lab	Elective	3 (1-6)
15				Cyber Security Lab	Elective	3 (1-6)
				Mathematics Supporting Courses (3/72) 1 Course		
16	2	MT1xx	CAG	Linear Algebra	Maths	3 (3-0)
				General Education Requirement (21/72) 8 Courses		
17	1	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
18	1	GE1xx		Functional English	GER	3 (3-0)
19	2	GE1xx	ECC	Expository Writing	GER	3 (3-0)
20	1	GE1xx		Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
21	1	GE1xx		Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
22	4	GE2xx		Islamic Studies	GER	2 (2-0)
23	8	GE4xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
24	4	GE2xx		Entrepreneurship	GER	2 (2-0)

5.5.1 Suggested Semester/Study Plan for ADCS

#	Code	Pre-Reqs	Course Title	Domain	Cr Hr (Cont hr)
Semester 1					
1	CS1xx		Programming Fundamentals	Core	4 (3-3)
2	GE1xx		Application of Information & Communication Technologies	GER	3 (2-3)
3	GE1xx		QR 1 (Discrete Structures)	GER	3 (3-0)
4	GE1xx		QR 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
5	GE1xx		Functional English	GER	3 (3-0)
				Total Cr Hrs	**16 (14-6)**
Semester 2					
6	CS1xx		Object Oriented Programming	Core	4 (3-3)
7	CS1xx		Database Systems	Core	4 (3-3)
8	CS1xx		Digital Logic Design	Core	3 (2-3)
9	MT1xx		Linear Algebra	Maths	3 (3-0)
10	GE1xx		Expository Writing	GER	3 (3-0)
				Total Cr Hrs	**17 (14-9)**
Semester 3					
11	CS2xx		Data Structures	Core	4 (3-3)
12	CS2xx		Information Security	Core	3 (2-3)
13	CS2xx		Artificial Intelligence	Core	3 (2-3)
14	CS2xx		Computer Networks	Core	3 (2-3)
15	CS2xx		Software Engineering	Core	3 (3-0)
16	CS2xx		Computer Organization & Assembly Language	Core	3 (2-3)
				Total Cr Hrs	**19 (14-15)**
Semester 4					
17	CS2xx		Elective 1 (Example: Advanced Database Lab)	Elective	2 (0-6)
18	CS2xx		Elective 2 (Example: Web Technologies Lab)	Elective	3 (1-6)
19	CS2xx		Elective 3 (Example: Mobile Application Development Lab)	Elective	3 (1-6)
20	CS2xx		Elective 4 (Example: Advanced Programming Lab)	Elective	3 (1-6)
21	CS2xx		Elective 5 (Example: Cyber Security Lab)	Elective	3 (1-6)
22	GE2xx		Islamic Studies	GER	2 (2-0)
23	GE2xx		Ideology and Constitution of Pakistan	GER	2 (2-0)
24	GE2xx		Entrepreneurship	GER	2 (2-0)
				Total Cr Hrs	**20 (10-30)**

6 List of Courses in BS Program

The following are offered under different and categories. Details of these courses such as suggested course code (in some cases), CrHr, domain and course contents are mentioned in next few sections.

S#	Title
1	Advanced Database Management Systems
2	Advanced Digital Logic Design
3	Advanced Statistics
4	Agent Based Modeling
5	Analysis of Algorithms
6	Analysis of Information Systems
7	Art for Games
8	Artificial Intelligence
9	Artificial Neural Networks & Deep Learning
10	Bacterial Genetics
11	Basic Biology & Cell Biology
12	Basic Electronics
13	Basic General Chemistry
14	Big Data Analytics
15	Bioelectronics and Biosensors
16	Bioinformatics & Scientific Computing
17	Business Process Analysis
18	Cloud Computing
19	Compiler Construction
20	Computer Aided Drug Designing
21	Computer Architecture
22	Computer Graphics
23	Computer Interfacing
24	Computer Networks
25	Computer Organization & Assembly Language
26	Computer Vision
27	Contract Management
28	Control Engineering
29	Control System Security
30	Cryptanalysis
31	Cyber Law & Cyber Crime (Cyber Warfare)
32	Cyber Security
33	Cyber Security Lab
34	Data Mining
35	Data Science
36	Data Structures
37	Data Visualization
38	Data Warehousing & Business Intelligence
39	Database Systems
40	DB Administration & Management
41	Deep Learning
42	Digital Forensics
43	Digital Image Processing
44	Digital Logic Design
45	Digital Signal Processing
46	Digital System Design
47	Electrical Network Analysis
48	Electronic Devices & Circuits
49	Embedded Systems
50	Embedded Systems Security
51	Enterprise Resource Planning Systems
52	Enterprise Systems
53	Ethical & Legal Issues in Bioinformatics

54	Evolutionary Biology
55	Evolutionary Computing
56	Final Year Project - I
57	Final Year Project - II
58	Foreign Languages (one or two languages)
59	Fundamentals of Genetics
60	Fuzzy Systems
61	Game Design and Development
62	Game Programming
63	Game Project Management
64	Genomics
65	Hardware Security
66	HCI & Computer Graphics
67	Information Assurance
68	Information Security
69	Information System Security
70	Information System Theory
71	Information Technology Infrastructure
72	Interactive Games and Audio
73	Intro to Bioinformatics & Computational Biology
74	Introduction to Biotechnology
75	Introduction to Data Science
76	Knowledge Based Systems
77	Knowledge Representation & Reasoning
78	Linear Circuit Analysis
79	Machine Learning
80	Malware Analysis
81	Management of Information Systems
82	Methods in Molecular Biology
83	Microbiology
84	Mobile Application Development 1
85	Mobile Application Development 2
86	Mobile Application Development Lab
87	Mobile Games & Entertainment
88	Mobile Multimedia
89	Multicore & GPU Programming
90	Nano Technology
91	Natural Language Processing
92	Network Security
93	Numerical Analysis
94	Object Oriented Analysis & Design
95	Object Oriented Programming
96	Operating Systems
97	Parallel & Distributed Computing
98	Parallel Computer Architectures
99	Penetration Testing
100	Platforms & Architectures for Data Science
101	Programming for 3D & Web 3D Apps
102	Programming for AI
103	Programming Fundamentals
104	Project Management
105	Reinforcement Learning
106	Secure Software Design and Development
107	Service and Operation Management
108	Signals & Systems
109	Software Construction & Development
110	Software Design & Architecture
111	Software Engineering
112	Software Project Management
113	Software Quality Engineering
114	Software Re-Engineering

115	Software Requirement Engineering
116	Software Testing & Quality Assurance
117	Software Verification and Validation (Testing & QA)
118	Speech Processing
119	Swarm Intelligence
120	System & Network Administration
121	System Analysis
122	Text Mining
123	Theory of Automata
124	Topics in Data Science
125	Video Games & Creative Writing
126	Video Production Techniques
127	Virtual Systems & Services
128	Visual Programming
129	Visual Programming Lab
130	Vulnerability Assessment & Reverse Engineering
131	Web Applications and Services
132	Web Engineering
133	Web Technologies
134	Web Technologies Lab
135	Wireless and Mobile Security
	Maths & General Education Courses
1	Multivariable Calculus
2	Differential Equations
3	Linear Algebra
4	Probability & Statistics
5	Functional English
6	Expository Writing
7	Technical & Business Writing
8	Quantitative Reasoning 1 – QR 1 (Discrete Structures)
9	Quantitative Reasoning 2 – QR 2 (Calculus and Analytic Geometry)
10	Civilizational Courses - Islamic Studies
11	Civilizational Courses - Ideology and Constitution of Pakistan
12	Arts & Humanities (Professional Practices)
13	Social Science (Example: Introduction to Management)
14	Natural Science (Applied Physics)
15	Social Science Elective (Example: Introduction to Marketing)
16	Application of Information & Communication Technologies
17	Entrepreneurship
18	Civics and Community Engagement

7 Course Contents

Preparation and making of course contents are essential parts of the curriculum development. Primarily it is the responsibility of the program executers to design courses contents keeping in mind the overall goal of the program. In order to facilitate universities/DAIs, detailed course contents are given for common courses only. There are about 29 courses which are common to all degree offered under the computing discipline. These common courses are divided into three different categories which are given in the tables below. The course contents of these courses are given on next few pages. The Bloom's Taxonomy is also identified as C = Cognitive domain, P = Psychomotor domain, A = Affective domain with each course. CLOs are also defined with each course.

Table no. 7.1 List of Computing Core Courses for which Course contents are given

#	Code	Course Title	Domain	Cr Hr
1	CS1xx	Programming Fundamentals	Computing Core	4 (3-3)
2	CS1xx	Object Oriented Programming	Computing Core	4 (3-3)
3	CS1xx	Database Systems	Computing Core	4 (3-3)
4	CS1xx	Digital Logic Design	Computing Core	3 (2-3)
5	CS2xx	Data Structures	Computing Core	4 (3-3)
6	CS2xx	Information Security	Computing Core	3 (2-3)
7	CS2xx	Artificial Intelligence	Computing Core	3 (2-3)
8	CS2xx	Computer Networks	Computing Core	3 (2-3)
9	CS2xx	Computer Organization & Assembly Language	Computing Core	3 (2-3)
10	CS2xx	Software Engineering	Computing Core	3 (3-0)
11	CS3xx	Operating Systems	Computing Core	3 (2-3)
12	CS4xx	Analysis of Algorithms	Computing Core	3 (3-0)
13	CS4xx	Final Year Project – I*	Computing Core	2 (0-6)
14	CS4xx	Final Year Project – II*	Computing Core	4 (0-12)

***course contents are not applicable.**

Table no. 7.2 Mathematics & Supporting Courses – Course Contents

#	Code	Course	Domain	Cr Hr
1	MT1xx	Multivariable Calculus	Maths	3 (3-0)
2	MT2xx	Probability & Statistics	Maths	3 (3-0)
3	MT2xx	Linear Algebra	Maths	3 (3-0)
4	EW	Technical & Business Writing	EW	3 (3-0)

Table no. 7.3 General Education Requirement as per HEC UG Education Policy Course Contents

#	Code	Course	Domain	Cr Hr
1	GE1xx	Application of Information & Communication Technologies	GER	3 (2-3)
2	GE1xx	Functional English	GER	3 (3-0)
3	GE1xx	Expository Writing	GER	3 (3-0)
4	GE1xx	Quantitative Reasoning – 1 (Discrete Structures)	GER	3 (3-0)
5	GE1xx	Quantitative Reasoning – 2 (Calculus and Analytic Geometry)	GER	3 (3-0)
6	GE2xx	Islamic Studies	GER	2 (2-0)
7	GE4xx	Ideology and Constitution of Pakistan	GER	2 (2-0)
8	GE2xx	Social Sciences (Example: Introduction to Management)#	GER	2 (2-0)
9	GE2xx	Natural Sciences (Applied Physics)	GER	3 (2-3)
10	GE4xx	Arts & Humanities (Professional Practices)	GER	2 (2-0)
11	GE4xx	Civics and Community Engagement	GER	2 (2-0)
12	GE4xx	Entrepreneurship	GER	2 (2-0)

#University shall prepare course contents for these courses or the university may offer some other course instead of these courses from the same area.

Table no. 7.4 Artificial Intelligence Core– Course Contents

#	Code	Course	Domain	CrHr
1		Artificial Neural Networks & Deep Learning	Artificial Intelligence Core	3 (2-3)
2		Computer Vision	Artificial Intelligence Core	3 (2-3)
3		Knowledge Representation and Reasoning	Artificial Intelligence Core	3 (3-0)
4		Machine Learning	Artificial Intelligence Core	3 (2-3)
5		Natural Language Processing	Artificial Intelligence Core	3 (2-3)
6		Programming for Artificial Intelligence	Artificial Intelligence Core	3 (2-3)

Table no. 7.5 Data Science Core– Course Contents

#	Code	Course	Domain	CrHr
1		Advance Statistics	Data Science Core	3 (3-0)
2		Big Data Analytics	Data Science Core	3 (2-3)
3		Data Mining	Data Science Core	3 (2-3)
4		Data Visualization	Data Science Core	3 (2-3)
5		Data Warehousing and Business Intelligence	Data Science Core	3 (2-3)
6		Introduction to Data Science	Data Science Core	3 (2-3)

Table no. 7.6 Cyber Security Core– Course Contents

#	Code	Course	Domain	CrHr
1		Digital Forensics	Cyber Security Core	3 (2-3)
2		Information Assurance	Cyber Security Core	3 (3-0)
3		Introduction to Cyber Security	Cyber Security Core	3 (2-3)
4		Network Security	Cyber Security Core	3 (2-3)
5		Secure Software Design and Development	Cyber Security Core	3 (2-3)
6		Vulnerability Assessment & Reverse Engineering	Cyber Security Core	3 (2-3)

Table no. 7.7 Artificial Intelligence Elective – Course Contents

#	Code	Course	Domain	CrHr
1		Deep Learning	Artificial Intelligence Elective	3 (2-3)
2		Theory of Automata & Formal Languages	Artificial Intelligence Elective	3 (2-3)

Table no. 7.8. Data Science Elective– Course Contents

#	Code	Course	Domain	CrHr
1		Advance Database Management Systems	Data Science Elective	3 (2-3)

Course Contents of Computing Core

Course Name:	***Programming Fundamentals***
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.

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

Course Outline:

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

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

1. Starting out with Programming Logic & Degins, 4th Edition, Tony Gaddis,
2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
3. Object Oriented Programming in C++ by Robert Lafore
4. C How to Program, 7th Edition by Paul Deitel & Harvey Deitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Course Name:	***Object Oriented Programming***
Credit Hours:	4 (3-3)
Contact Hours:	3-3
Pre-requisites:	Programming Fundamentals

Course Introduction:

The course aims to focus on object-oriented concepts, analysis and software development. The basic concept of OOP is covered in this course.

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

Course Outline:

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

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

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

Course Name:	***Data Structures***
Credit Hours:	4 (3-3)
Contact Hours:	3-3
Pre-requisites:	Programming Fundamentals

Course Introduction:

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

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

Course Outline:

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

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

1. Data Structures and Algorithm Analysis in Java by Mark A. Weiss
2. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
3. Data Structures and Algorithms in C++ by Adam Drozdek
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss

   Java Software Structures: Designing and Using Data Structures by John Lewis and Joseph Chase

Course Name:	***Computer Organization and Assembly Language***
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 as a tool. At the end of the course the students should be capable of writing moderately complex assembly language subroutines and interfacing them to any high level language.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Acquire the basic knowledge of computer organization computer architecture and assembly language	C2 (Understand)
CLO-2	Understand the concepts of basic computer organization, architecture, and assembly language techniques	C2 (Understand)
CLO-3	Solve the problems related to computer organization and assembly language	C3 (Apply)

Course Outline:

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

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

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

Course Name:	***Digital Logic Design***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction:

The course introduces the concept of digital logic, gates and the digital circuits. Further, it focuses on the design and analysis combinational and sequential circuits. It also serves to familiarize the student with the logic design of basic computer hardware components.

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

Course Outline: (or use any other standard and latest books)

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey method), Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Mealy machines and Moore machines. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA) Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.

Reference Materials:

1. Digital Fundamentals by Floyd, 11/e.
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e

Course Name:	***Operating Systems***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Data Structures

Course Introduction:

To help students gain a general understanding of the principles and concepts governing the functions of operating systems and acquaint students with the layered approach that makes design, implementation and operation of the complex OS possible.

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

Course Outline:

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

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

1.Operating Systems Concepts, 9th edition by Abraham Silberschatz

2.Modern Operating Systems, 4th edition by Andrew S. Tanenbaum

3.Operating Systems, Internals and Design Principles, 9th edition by William StallingsWu

Course Name:	***Database System***
Credit Hours:	4 (3-3)
Contact Hours:	3-3
Pre-requisites:	None

Course Introduction:

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

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

Course Outline:

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

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

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

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

Course Outline:

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

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

1. Computer Security: Principles and Practice, 3rd edition by William Stallings
2. Principles of Information Security, 6th edition by M. Whitman and H. Mattord
3. Computer Security, 3rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom
5. Official (ISC)2 Guide to the CISSP CBK, 3rd edition

Course Name:	***Computer Networks***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction:

This course introduces the basic concept of computer network to the students. Network layers, Network models (OSI, TCP/IP) and protocol standards are part of the course.

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

Course Outline:

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

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

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

Course Name: ***Software Engineering***
Credit Hours: 3 (3-0)
Contact Hours: 3-0
Pre-requisites: None

Course Introduction:

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

Course Outline:

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

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

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

Course Name: ***Analysis of Algorithms***
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 Taxonomy
CLO-1	Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm	
CLO-2	Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.	
CLO-3	Determine informally the time and space complexity of simple algorithms	
CLO-4	List and contrast standard complexity classes	
CLO-5	Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms	
CLO-6	Use of the strategies(brute-force, greedy, divide-and-conquer, and dynamic programming) to solve an appropriate problem	
CLO-7	Solve problems using graph algorithms, including single-source and all-pairs shortest paths, and at least one minimum spanning tree algorithm	
CLO-8	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 Materials: (or use any other standard and latest books)

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

Course Name:	***Artificial Intelligence***
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 Taxonomy
CLO-1	Understand the fundamental constructs of Python programming language.	C2 (Understand)
CLO-2	Understand key concepts in the field of artificial intelligence	C2 (Understand)
CLO-3	Implement artificial intelligence techniques and case studies	C3 (Apply)

Course Outline:

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

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

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

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

Course Introduction:

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

Course Outline:

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

Reference Materials:

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

Course Contents of Mathematics & Supporting Courses

Course Name:	***Calculus and Analytic Geometry***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction:

To provide foundation and basic ground for calculus and analytical geometry background.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of funding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential calculus; Concept and idea of differentiation, Geometrical and Physical meaning of derivatives, Rules of differentiation, Techniques of differentiation, Rates of change, Tangents and Normals lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation; Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity, Integral calculus; Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve, Analytical Geometry; Straight lines in R3, Equations for planes.

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

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

Course Name: ***Linear Algebra***
Credit Hours: 3 (3-0)
Contact Hours: 3-0
Pre-requisites: Calculus and Analytical Geometry

Course Introduction:

To provide fundamentals of solution for system of linear equations, operations on system of equations, matrix properties, solutions and study of their properties.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

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

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

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

Course Name: ***Probability and Statistics***
Credit Hours: 3 (3-0)
Contact Hours: 3-0
Pre-requisites: None

Course Introduction:

To introduce the concepts of data analysis, presentation, counting techniques, probability and decision making.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, FQuantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of PValues for Decision Making in Testing Hypotheses (Single Sample & One- and TwoSample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

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

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

Course Contents of General Education Courses

Course Name:	***Functional English***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction:

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

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

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

1. College Writing Skills with Readings, by John Langan, McGraw-Hill, 5th Edition.
2. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute, 2000

Course Name:	***Expository Writing***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Functional English

Course Introduction:

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

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

1. Practical Business English, Collen Vawdrey, 1993, ISBN = 0256192740
2. Effective Communication Skills: The Foundations for Change, John Nielsen, 2008, ISBN = 1453506748
3. College Writing Skills with Readings, by John Langan, McGraw-Hill, 5th Edition.
4. A Textbook of English Prose and Structure by Arif Khattak, et al, GIKI Institute, 2000

Course Name:	***Technical and Business Writing***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Communication and Presentation Skills

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 Taxonomy
-	-	-

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, Leaflets, brochures, handbooks, magazines articles, research papers, feasibility reports, project reports, technical research reports, manuals and documentation, thesis. Electronic documents, Linear verses hierarchical structure documents.

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

1. Technical Report Writing, by Pauley and Riordan, Houghton Mifflin Company, 8th Edition.
2. Effective Technical Communication by Ashraf Rizvi, Tata McGraw-Hill.

Course Name:	***Islamic Studies***
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 Taxonomy
1	• To further enhance the knowledge of Islam.	
2	• To understand the basic concept of Islam and Quran Pak.	
3	• To understand the concept of Haqooq ul ibad in the light of Quran.	
4	• To know the importance of Islamic concept about other religions.	-

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

1. Introduction to Islam by Dr Hamidullah, Papular Library Publishers Lahore
2. Principles of Islamic Jurisprudence by Ahmad Hassan, Islamic Research Institute, IIUI
3. Muslim Jurisprudence and the Quranic Law of Crimes, By Mir Waliullah, Islamic Books Services

Course Name:	***Ideology and Constitution of Pakistan***
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 Taxonomy
1	• To educate students about the history of Pakistan	
2	• To educate student about the various pillar of the state	
3	• To educate student Government and politics	

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

1. The Emergence of Pakistan, Chaudary M., 1967
2. The making of Pakistan, Aziz. 1976
3. A Short History of Pakistan, I. H. Qureshi, ed., Karachi, 1988

Course Name:	***Professional Practices***
Credit Hours:	2 (2-0)
Contact Hours:	2-0
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, and assess ethical and professional computing case studies.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
-	-	-

Course Outline:

Historical, social, and economic context of Computing (software engineering, Computer Science, Information Technology); Definitions of Computing (software engineering, Computer Science, Information Technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities, software related contracts, Software house organization. Intellectual Property Rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse and the Criminal Law, Regulation and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct, ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.

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

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

Course Name:	***Discrete Structure***
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 Taxonomy
CLO-1	Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.	C2 (Understand)
CLO-2	Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	C3 (Apply)
CLO-3	Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C3 (Apply)
CLO-4	Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular	C4 (Differentiate)

Course Outline:

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

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

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

Course Name:	***Applied Physics***
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 Taxonomy
-	-	-

Course Outline:

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

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

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

Course Name:	***Introduction to Information and Communication Technologies***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	None

Course Introduction:

This is an introductory course in Computer Science designed for beginners. Apart from leading the participants through a whirlwind history of computing, the course also develops a feel for web programming through a series of lectures that help the students develop their own web page. Main objective of the course is to build an appreciation for the fundamental concepts in computing and to become familiar with popular PC productivity software.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand basics of computing technology	C1 (Knowledge)
CLO-2	Do number systems conversions and arithmetic	C2(Understand)
CLO-3	Have knowledge of types of software	C2(Understand)
CLO-4	Have knowledge of computing related technologies	C3 (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 (Super, Mainframe, Mini and Micro 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, Some Common Services available on Internet.

Reference Materials:

1. Charles S. Parker, Understanding Computers: Today and Tomorrow, Course Technology, 25 Thomson Place, Boston, Massachusetts 02210, USA
2. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017.
3. Zawacki-Richter, Olaf, and Colin Latchem. "Exploring four decades of research in Computers & Education." Computers & Education 122 (2018): 136-152.
4. Sinha, Pradeep K., and Priti Sinha. Computer fundamentals. BPB publications, 2010.
5. Goel, Anita. Computer fundamentals. Pearson Education India, 2010.

Course Name:	***Artificial Neural Networks & Deep Learning***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Programming for Artificial Intelligence

Course Introduction:

This course will introduce Artificial Neural Networks and Deep Learning. ANN's basic architecture and how they mimic the human brain using simple mathematical models. Many of the important concepts and techniques around brain computing and the major types of ANN will also be introduced. Emphasis is made on the mathematical models, understanding learning laws, selecting activation functions and how to train the networks to solve classification problems. Deep neural networks have achieved state of the art performance on several computer vision and speech recognition benchmarks. This course will further build on the fundamentals of Neural networks and artificial intelligence and will introduce advanced topics in neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of neural networks in AI	C2 (Understand)
CLO-2	Explain how simple ANNs can be designed	C2 (Understand)
CLO-3	Apply ANN for classification Problems	C3 (Apply)
CLO-4	Apply deep learning algorithms to real-world problems	C3 (Apply)
CLO-5	Analyze results from deep learning to select appropriate solutions	C4 (Analyze)

Course Outline:

Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification. Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Selected topics from: Gradient descent (Delta) rule, Hebbian, Neo-Hebbian and Differential Hebbian Learning, Drive Reinforcement Theory, Kohonen Self Organizing Maps, Associative memory, Bi-directional associative memory (BAM), Energy surfaces, The Boltzmann machines, Backpropagation Networks, Feedforward Networks; Theory of Generalization; Multi-layer perceptrons, error back-propagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc

Reference Materials:

1. Neural Network Design, 2nd Edition, Martin T. Hagan, Howard, B. Demuth, Mark Hudson Beale and Orlando De Jesus, Publisher: Martin Hagan; 2 edition (September 1, 2014), ISBN-10: 0971732116
2. An Introduction to Neural Networks, James A Anderson, Publisher: A Bradford Book (March 16, 1995), ISBN-10: 0262011441

3. Fundamentals of Artificial Neural Networks, Mohammad Hassoun, Publisher: A Bradford Book (January 1, 2003), ISBN-10: 0262514672
4. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville (http://www.deeplearningbook.org/)
5. Deep learning with python by Francoise Chollet, ISBN-10: 9781617294433, 2017

Course Name: ***Computer Vision***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Artificial Neural Networks & Deep Learning

Course Introduction:

With a single glance a human interprets the entire scene. How many objects are present in the scene and where they are located. Which person is present in the scene. What will happen next. However, computers lack this capability. We have seen only face detectors so far working in our mobile phones? What is the challenge in understanding the 3D scene, i.e., the identity, the location and the size of the objects present in the scene. In this course we will introduce the basic concepts related to 3D scene modelling from single view and multiple views.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understanding the single view geometry concepts	C2 (Understand)
CLO-2	Understanding the multiple view geometry concepts	C2 (Understand)
CLO-3	Apply concepts of CV for solving real world problems	C3 (Apply)

Course Outline:
Introduction to Computer Vision (Problems faced, History and Modern Advancements). Image Processing, Image filtering, Image pyramids and Fourier transform, Hough transform. Camera models, Setting up a camera model from parameters, Camera looking at a plane, Relationship of plane and horizon line, Rotation about camera center. Concatenation, Decomposition and Estimation of transformation from point correspondences, Points and planes in 2D/3D, Transformations in 2D/3D, Rotations in 2D/3D. Edge detection, corner detection. Feature descriptors and matching (HoG features, SIFT, SURF). Applications of Computer Vision Traditional Methods: Image Stitching: Making a bigger picture from smaller pictures Single View Geometry: Converting a single image into a 3D model. Applications of CV using Deep Learning: Image Detection (Localization, Historical Techniques, RCNN, FRCNN, YOLO, Retina), Image Segmentation (UNet, SegNet, MaskRCNN), Image Generation (GANN)

Reference Materials:

Text Book:

1. Computer Vision: Algorithms and Applications, by Richard Szeliski.

Reference Book:

2. Multiple View Geometry in Computer Vision, by Richard Hartley and Andrew Zisserman.
3. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce.
4. Digital Image Processing, by Rafael Gonzalez and Richard Woods.

Course Name:	***Knowledge Representation and Reasoning***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Artificial Intelligence

Course Introduction:

Knowledge representation is one of the fundamental areas of Artificial Intelligence. It is the study of how knowledge about the world can be represented and manipulated in an automated way to enable agents to make intelligent decisions. This course will provide an overview of existing knowledge representation frameworks developed within AI including but not limited to propositional and first-order logic, ontologies, planning, reasoning and decision making under uncertainty. The assignments component of the course would provide hands-on experience of software like Prolog, Protégé, probabilistic reasoning APIs and tools to support complex decision making. It is expected that after completing this course, students will understand (a) the foundations of Knowledge Representation & Reasoning and (b) which tools and techniques are appropriate for which tasks.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamentals of knowledge representation and reasoning in deterministic situations	C2 (Understand)
CLO-2	Understand the challenges in representing knowledge and reasoning under uncertainty	C2 (Understand)
CLO-3	Analyze different situations and apply appropriate knowledge representation frameworks	C4 (Analyze)
CLO-4	Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems.	C4 (Analyze)

Course Outline:

Propositional Logic, First-order Logic, Horn Clauses, Description Logic, Reasoning using Description Logic, Forward and Backward Chaining in Inference Engines, Semantic Networks, Ontologies and Ontology Languages, Logical Agents, Planning, Rule-based Knowledge Representation, Reasoning Under Uncertainty, Bayesian Networks Representation, Inference in Bayesian Networks, Fuzzy Logic, Inferene using Fuzzy Rules, Markov Models, Commonsense Reasoning, Explainable AI.

Reference Materials:

1. Stuard Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd Ed.) (2015)
2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 2nd Ed, 2017
3. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning, 2004

Course Name: ***Machine Learning***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Artificial Intelligence

Course Introduction:

Machine learning is one of the fastest growing areas of computer science, with far-reaching applications. The aim of this course is to: a) Present the basic machine learning concepts; b) Present a range of machine learning algorithms along with their strengths and weaknesses; c) Apply machine learning algorithms to solve problems of moderate complexity.

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

Course Outline:

Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Aglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and 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 Materials:

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

Course Name: ***Natural Language Processing***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Artificial Neural Networks & Deep Learning

Course Introduction:

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand techniques for information retrieval, language translation, and text classification.	C2 (Understand)
CLO-2	Understand the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks.	C2 (Understand)
CLO-3	Understand and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each	C2 (Understand)
CLO-4	Solve classic and stochastic algorithms for parsing natural language.	C3 (Apply)

Course Outline:

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

Reference Materials:

1. Daniel Jurafsky and James H. Martin. 2018. Speech and Language Processing: An Introduction to Natural Language Processing. Third Edition. Prentice Hall
2. Foundations of Statistical Natural Language Processing, Manning and Schütze, MIT Press. Cambridge, MA: May 1999

Course Name: ***Programming for Artificial Intelligence***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Artificial Intelligence

Course Introduction:

This course aims to introduce standard programming practices and to help develop programming skills necessary for designing and implementing Artificial Intelligence systems. The course introduces classical as well as modern state of the art programming language for Artificial Intelligence (Lisp, Prolog, Python, and R), and builds up the necessary programming background for the main courses like Machine Learning, Artificial Neural Networks & Deep Learning, Natural Language Processing, and Speech Processing. This course will help the students of Artificial Intelligence develop the programming acumen and style. The ultimate aim of this course is to help students in using the AI programming languages to solve problems of interest to them.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamental constructs of Lisp, Prolog, and Python programming languages.	C2 (Understand)
CLO-2	Comprehend the fundamental constructs of programming languages for data analysis and representation.	C2 (Understand)
CLO-3	Understand and apply the Object-oriented concepts in the programming languages.	C2 (Understand)
CLO-4	Apply various libraries for plotting, interpreting and analyzing data in Python.	C3 (Apply)

Course Outline:

The first objective of the course is to introduce and then build the proficiency of students in different AI programming languages. The basics include IDE for the languages, variables, expressions, operands and operators, loops, control structures, debugging, error messages, functions, strings, lists, object-oriented constructs and basic graphics in the languages. Special emphasis is given to writing production quality clean code in the programming language. Once the classical programming languages are properly introduced, the course should introduce some libraries necessary for interpreting, analyzing and plotting numerical data in Python (e.g., NumPy, MatPlotLib, Anaconda and Pandas for Python) and give examples of each library using simple use cases and small case studies.

Reference Materials:

1. Russell, S. and Norvig, P. “Artificial Intelligence. A Modern Approach”, 3rd ed, Prentice Hall, Inc., 2015.
2. Norvig, P., “Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp”, Morgan Kaufman Publishers, Inc., 1992.
3. Luger, G.F. and Stubblefield, W.A., “AI algorithms, data structures, and idioms in Prolog, Lisp, and Java”, Pearson Addison-Wesley. 2009.
4. Severance, C.R., 2016. “Python for everybody: Exploring data using Python 3.” CreateSpace Independent Publ Platform.
5. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. “Python programming in context.” Jones & Bartlett Pub.
6. McKinney, W., 2012. “Python for data analysis: Data wrangling with Pandas, NumPy, and IPython.” O'Reilly Media, Inc.
7. Reference Book:
8. Joshi, P., 2017. “Artificial intelligence with python.” Packt Publishing Ltd.
9. Janert, P.K., 2010. “Data analysis with open source tools: a hands-on guide for programmers and data scientists.” O'Reilly Media, Inc.

Data Science Core

Course Name:	***Advance Statistics***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	Probability and Statistics

Course Introduction:

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Describe what part of statistics is meant for data scientist and what the applications of statistics in data science are.	C1 (Knowledge)
CLO-2	Apply Statistical techniques in real life problems.	C3(Apply)
CLO-3	Analyze, Correlate, Forecast data by using different statistical techniques	C2 (Understand)
CLO-4	Apply basic data science statistical techniques by using SPSS on real world datasets.	C3 (Apply)

Course Outline:

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

Reference Materials:

1. Probability and Statistics for Computer Scientists, 2nd Edition, Michael Baron.
2. Probability for Computer Scientists, online Edition, David Forsyth
3. Discovering Statistics using SPSS for Windows, Andy Field

Course Name:	***Big Data Analytics***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Introduction to Data Science

Course Introduction:

The course objective is to develop understanding about the core concept of Big Data, why Big Data requires a different programming paradigm and mindset, and what are the various programming approaches used, what type of data can be processed.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Understand the fundamental concepts of Big Data and its programming paradigm.	C2 (Understand)
CLO-2	Hadoop/MapReduce Programming, Framework, and Ecosystem	C3 (Apply)
CLO-3	Apache Spark Programming	C3 (Apply)

Course Outline:

Introduction and Overview of Big Data Systems; Platforms for Big Data, Hadoop as a Platform, Hadoop Distributed File Systems (HDFS), MapReduce Framework, Resource Management in the cluster (YARN), Apache Scala Basic, Apache Scala Advances, Resilient Distributed Datasets (RDD), Apache Spark, Apache Spark SQL, Data analytics on Hadoop / Spark, Machine learning on Hadoop / Spark, Spark Streaming, Other Components of Hadoop Ecosystem

Reference Materials:

1. White, Tom. “Hadoop: The definitive guide." O'Reilly Media, Inc., 2012.
2. Karau, Holden, Andy Konwinski, Patrick Wendell, and Matei Zaharia. “Learning spark: lightning-fast big data analysis." O'Reilly Media, Inc., 2015.
3. Miner, Donald, and Adam Shook. “MapReduce design patterns: building effective algorithms and analytics for Hadoop and other systems." O'Reilly Media, Inc., 2012.

Course Name:	***Data Mining***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Advance Statistics, Introduction to Data Science

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.
The aims of this course are to:

- Expand on the student's understanding and awareness of the concepts of data mining basics, techniques, and application.
- Introduce the concepts of ***Data Pre-processing and Summary Statistics***.
- Introduce the concepts of ***Frequent Item Set Generation, Associations and Correlations measures***.
- Introduce the concepts of ***Classification, Prediction, and Clustering algorithms***.

Build on the programming and problem-solving skills developed in previous subjects studied by the student, to achieve an understanding of the development of Classification, Prediction, and Clustering applications.

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

Course Outline:

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

Reference Materials:

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

Course Name: ***Data Visualization***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Data Warehousing & Business Intelligence

Course Introduction:

Data Visualization is a process of obtaining detailed insights hidden in the data. It is a necessary component in the pipeline of any data science project. This course teaches skills specifically in terms of how to effectively present the data and findings. Further, this course provides hands on skills using R for data exploration and visualization.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Provides knowledge about importance, necessity, and justification of performing exploratory data analysis and visualization	C2 (Understand)
CLO-2	Introduce various type of charts along with their alternatives solution to show same data from versatile aspects.	C2 (Understand)
CLO-3	Improving the competency of the students to analyze different problems and select the most appropriate solution.	C3 (Apply)
CLO-4	Use of R, various recent tools, and technologies to develop hands-on skills for exploratory data analysis and visualization.	C3 (Apply)

Course Outline:
Introduction of Exploratory Data Analysis and Visualization, Building Blocks and Basic Operations; Types of Exploratory Graphs, single and multi-dimensional summaries, five number summary, box plots, histogram, bar plot and others; Distributions, their representation using histograms, outliers, variance; Probability Mass Functions and their visualization; Cumulative distribution functions, percentile-based statistics, random numbers; Modelling distributions, exponential, normal, lognormal, pareto; Probability density functions, kernel density estimation; Relationship between variables, scatter plots, correlation, covariance; Estimation and Hypothesis Testing; Clustering using K-means and Hierarchical; Time series and survival analysis; Implementing concepts with R (or similar language)

Reference Materials:
1. "Exploratory Data Analysis with R" by Roger D. Peng

Course Name: ***Data Warehousing and Business Intelligence***
Credit Hours: 2-1
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 Outcomes	Bloom Taxonomy
CLO-1	Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process	C2 (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.	C2 (Understand)
CLO-3	Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas	C3 (Apply)
CLO-4	Use Analytic SQL to aggregate, analyze and report, and model data.	C3 (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 Materials:

1. W. H. Inmon, “Building the Data Warehouse”, Wiley-India Edition.
2. Ralph Kimball, “The Data Warehouse Toolkit – Practical Techniques for Building Dimensional Data Warehouse,” John Wiley & Sons, Inc.
3. Matteo Golfarelli, Stefano Rizzi, “Data Warehouse Design - Modern Principles and Methodologies”, McGraw Hill Publisher

Course Name: ***Introduction to Data Science***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
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 Outcomes	Bloom Taxonomy
CLO-1	Describe what Data Science is and the skill sets needed to be a data scientist.	C2 (Understand)
CLO-2	Apply EDA and the Data Science process in a case study.	C3 (Apply)
CLO-3	Comprehend the fundamental constructs of Python programming language.	C2 (Understand)
CLO-4	Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C3 (Apply)

Course Outline:

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

Reference Materials:

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

Course Name: ***Digital Forensics***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Introduction to Cyber Security

Course Introduction:

This course is an introduction to computer forensics and investigation. It provides an understanding of how to conduct investigations to correctly gather, analyze and present digital evidence to different audiences. It also outlines the tools to locate and analyze digital evidence on a variety of devices, how to keep up to date with changing technologies, and laws and regulations in digital forensics.

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

Course Outline:

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

Reference Materials:

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

Course Name: ***Information Assurance***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: None

Course Introduction:

To understand the role and interaction of policies, laws, procedures, management issues, and technical issues in protecting information resources.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Apply security governance principles; organizational processes; developing and implementing a documented security policy.	C3 (Apply)
CLO-2	Understand and apply risk management concepts	C2 (Understand)
CLO-3	To understand the business, legal, and technical knowledge needed to secure vital government and business assets.	C2 (Understand)

Course Outline:

Introduction to (IS) Information System (Concept, Design, Functions, Architecture, Components and applications of IS); Secure System Planning and Administration; Information Security Policies and Procedures; Asset Management; Organizational and Human Security; Cyber Security Management Concepts; NIST Cyber Security Framework; Enterprise Roles and Structures; Strategic Planning; Security Plans and Policies; Contingency Planning; Laws;

Laws and Regulatory Requirements; Security Standards and Controls, Risk Management Process, NIST Risk Management Framework, Security Metrics and Key Performance Indicators (KPIs); Physical Security and Environmental Events; Contingency Planning; Security Education, ISO 27001 Compliance, Training, and Awareness.

Reference Materials:

1. Principles of Information Security by Michael E. Whitman, 6th Edition, 2017
2. Reference Material: CISSP Study Guide, 7th Edition
3. Information Assurance: Managing Organizational IT Security Risks by Joseph Boyce and Daniel Jennings, 1 Edition or Latest
4. Information Assurance: Security in the Information Environment by Andrew Blyth and Gerald L. Kovacich, Springer, 2nd Edition or Latest

Course Name:	***Introduction to Cyber Security***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Information Security

Course Introduction:

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

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To be able to identify computer system threats	C2 (Understand)
CLO-2	To be able to identify Malware attacks, and understand the stages of attack and payloads.	C2 (Understand)
CLO-3	Implement various cryptographic techniques and simulate attack scenarios	C3 (Apply)

Course Outline:

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

Reference Materials:

1. Computer Security Fundamentals by Chuck Easttom, 4th edition or latest
2. Security+ Guide to Network Security Fundamentals, by Mark Ciampa, 5th Edition
3. Security in Computing by C.P. Pfleeger, Prentice-Hall, 4th Edition or Latest

Course Name: ***Network Security***
Credit Hours: 3 (2-3)
Contact Hours: 2-3
Pre-requisites: Introduction to Cyber Security

Course Introduction:

The module aims to develop core competencies in the fields of Network security and offer the opportunity of learning the current network security landscape, understanding current threats and vulnerabilities and examining ways of developing effective countermeasures. It also provides a brief overview to network forensics for analyzing network traffic for the purposes of information gathering, legal evidence, or intrusion detection.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	To be able to understand network security threats and methods for security networks	C2 (Understand)
CLO-2	To be able to secure wired networks by deploying various methods	C3 (Apply)
CLO-3	To be able to secure wireless networks by deploying various methods	C3 (Apply)

Course Outline:

Introduction to network security, Networking Concepts and Protocols, Network Threats and Vulnerabilities, Network Security Planning and Policy, Access Control, Defense against Network Attacks, DOS and DDOS detection and prevention, Firewalls, Intrusion Detection and Prevention Systems, Antivirus Filtering, Naming and DNS Security, DNSSEC, IP security, Secure Sockets Layer, VPN, Packet Sniffing and spoofing, Honeypot, Ethernet Security, Wireless Security, Wireless Attacks, Wireless LAN Security with 802.11i, Wireless Security Protocols, Wireless Intrusion Detection, Physical access and Security, Tor Network, Network Forensics. Defense against Network Attacks.

Reference Materials:

1. Network Security Assessment: Know Your Network by Chris McNab, 3rd Edition or latest.
2. Corporate Computer Security, by Randall J. Boyle, 3th Edition
3. Bulletproof Wireless Security by Praphul Chandra
4. Network Security Essentials: Applications and Standards by William Stallings, 3rd Edition or Latest
5. Cryptography and Network Security Principles and Practices by William Stallings, Latest Edition

Course Name: ***Secure Software Design and Development***
Credit Hours: 3 (2-3)
Contact Hours: 2-3

Pre-requisites: Introduction to Cyber Security

Course Introduction:

The module aims to develop core competencies in the fields of Secure Software Concepts, Secure Software Requirements, Secure Software Design, Secure Software Implementation/Coding, and Secure Software Testing. The course details the software security activities that need to be incorporated throughout the software development lifecycle. It provides comprehensive coverage that includes the people, processes, and technology components of software, networks, and host defenses.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	A good comprehension of software security standards, models, processes and best practices that need to be incorporated throughout the software development lifecycle.	C2 (Understand)
CLO-2	Identify insecure programming patterns and the ability to replace them with secure alternatives.	C2 (Understand)
CLO-3	Know tools for software security analysis and testing, and the ability to use them in practice and understand their capabilities and limitations.	C3 (Apply)

Course Outline:

Secure software concepts; System issues; System properties; Software Project Time Management; Software Project Costing; Software Quality Assurance; Security Concepts in the SDLC; Risk management; Security standards (e.g., coding standards, NIST standards, Federal Information Processing Standards); Best practices (e.g., OWASP development guide, OWASP code review guide, OWASP testing guide); Security methodologies (e.g., Socratic Methodology, Operationally Critical Threat, Asset, and Vulnerability Evaluation, STRIDE and DREAD, Open Source Security Testing Methodology Manual); Security frameworks (e.g., Zachman Framework, Control Objectives for Information and Related Technology, Sherwood Applied Business Security Architecture (SABSA)); Regulations-Privacy and Compliance; Security Models (e.g., BLP Confidentiality Model, Clark and Wilson Model (Access Triple Model)); Trusted Computing; Secure Software Requirements (Sources for Security Requirements, Types of Security Requirements); Secure Software Design (Design consideration, Information Technology Security Principles and Secure Design, Designing Secure Design Principles); Design Processes; Secure Software Implementation/Coding; Software Development Methodologies; Common Software Vulnerabilities and Controls; Defensive Coding Practices—Concepts and Techniques; Code Vulnerabilities and Avoiding Polymorphic Malware Attacks: Buffer overflow, Format string

bug, Code vulnerabilities SQL Injection, Cross-site Scripting, Cross-site Request Forgery, Session management, Replication of vulnerabilities and exploitation; Secure Software Testing; Security Testing Methodologies; Software Security Testing; Software Acceptance; Legal Protection Mechanisms; Software Deployment- Operations- Maintenance and Disposal.

Reference Materials:

1. Official (ISC)2 Guide to the CSSLP (latest)
2. Software Security: Building Security In, 1st Edition by Gary McGraw

Course Name:	***Vulnerability Assessment & Reverse Engineering***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Introduction to Cyber Security

Course Introduction:

The course aims to develop core competencies in the field of vulnerability assessment covering software, networks and Web applications. It also covers reverse engineering techniques to analyze software, exploit targets, and defend against security threats like malware and viruses.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Basic Understanding of Hacking and Ethical Hacking.	C2 (Understand)
CLO-2	Apply techniques for vulnerability assessment and penetration testing.	C3 (Apply)
CLO-3	Understand Software vulnerabilities, Network vulnerabilities, Types of Malware and its Analysis.	C2 (Understand)

Course Outline:

Understanding the need for security assessments; Classifying vulnerabilities; Software vulnerabilities; Network vulnerabilities; Vulnerability assessment versus penetration testing; Vulnerability Assessment Tools; Vulnerability management Regulatory compliance; Calculating ROIs; Application review process; Pre-assessment; Code navigation; Code-auditing tactics; Memory corruption; understanding issues in programming languages; Steps in Reverse engineering, Common tools used for Reverse engineering; Binary Obfuscation techniques; Understanding core assembly concepts to perform malicious code analysis, Identifying key assembly logic structures with a disassembler, Malware analysis Types of malware analysis; Malware Taxonomy; Static analysis; Dynamic analysis; Malware Inspection; Malware analysis tools; Sandboxing and virtualization;

Reference Materials:

1. Finding and Fixing Vulnerabilities in Information Systems: The Vulnerability Assessment and Mitigation Methodology by Philip S. Anton
2. The Art of Software Security Assessment: Identifying and Preventing Software Vulnerabilities by Mark Dowd
3. Reversing: Secrets of Reverse Engineering by Eldad Eilam (latest edition)
4. Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software by Michael Sikorski (latest edition)

Course Name:	***Deep Learning***
Credit Hours:	3 (2-3)
Contact Hours:	2-3
Pre-requisites:	Artificial Neural Networks and Deep Learning

Course Introduction:

Deep neural networks have achieved state of the art performance on several compute vision and speech recognition benchmarks. Deep learning algorithms extract layered high and low-level features from raw data. With increasing non-line hidden layers, the discriminative power of the network improves. This course builds on the fundamentals of Neural networks and artificial intelligence and covers advanced topics in neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning. It also embeds applications of these algorithms to several real-world problem in computer vision, speech recognition, natural language processing, game theory, etc.

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Apply deep learning algorithms to real-world problems	C3 (Apply)
CLO-2	Analyze results from deep learning to select appropriate solutions	C4 (Analyze)
CLO-3	Code the novel neural network architectures from scratch and evaluating the performance on application specific standard benchmarks	C3 (Apply)

Course Outline:

Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Theory of Generalization; Multi-layer perceptrons, error back-propagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc

Reference Materials:

1. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville (http://www.deeplearningbook.org/)
2. Deep learning with python by Francoise Chollet, ISBN-10: 9781617294433, 2017

Course Name:	***Theory of Automata & Formal Languages***
Credit Hours:	3 (3-0)
Contact Hours:	3-0
Pre-requisites:	None

Course Introduction:

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc.	C2 (Understand)
CLO-2	Prove properties of languages, grammars and automata with rigorously formal mathematical methods	C2 (Understand)
CLO-3	Design of automata, RE and CFG	C3 (Apply)
CLO-4	Transform between equivalent NFAs, DFAs and REs	C3 (Apply)
CLO-5	Define Turing machines performing simple tasks	C2 (Understand)
CLO-6	Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.	C3 (Apply)

Course Outline:

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

Reference Materials:

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

Course Name:	***Advance Database Management Systems***
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 to introduce 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 Taxonomy
CLO-1	Understanding advance data models, technologies and approaches for building distributed database systems.	C2 (Understand)
CLO-2	Applying the models and approaches in order to become enabled to select and apply appropriate methods for a particular case	C3 (Apply)
CLO-3	To develop a database solution for a given scenario/ challenging problem in the domain of distributed database systems.	C3 (Apply)

Course Outline:

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

Reference Materials:

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