Curriculum / Scheme of Studies

of

Bachelor of Science in Data Science

(BS Data Science)

(4 Years Program)

(Applicable w.e.f. Fall 2025)

University of Education, Lahore

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1 Introduction to BS in Data Science Program

BS Data Science (BSDS) Program is an interdisciplinary field that uses scientific methods, algorithms, and systems to extract insights from structured and unstructured data. It involves data collection from various sources, cleaning and preprocessing for usability, exploratory data analysis (EDA) to identify patterns, and applying machine learning and statistical techniques for predictive modeling. Data visualization tools help represent insights, while big data technologies like Hadoop and Spark enable large-scale processing. Industries such as business analytics, healthcare, finance, e-commerce, and social media leverage data science for applications like fraud detection, disease prediction, recommendation systems, and targeted marketing. Popular tools include programming languages like Python, R, and SQL; frameworks like Pandas, Scikit-learn, and TensorFlow; and cloud platforms such as AWS and Google Cloud. Careers in data science range from data scientists and analysts to machine learning engineers and DS researchers, making it a highly sought-after field in today's data-driven world.

2 Program Vision Statement

The vision of a BS Data Science program is to empower individuals with the knowledge, skills, and tools needed to harness the power of data for impactful decision-making and innovation. It aims to cultivate expertise in data collection, analysis, machine learning, and big data technologies while fostering critical thinking and problem-solving abilities. By integrating interdisciplinary approaches, ethical considerations, and real-world applications, the program aspires to produce professionals who can drive advancements in industries such as healthcare, finance, business, and technology. Ultimately, the vision is to create a data-driven society where insights from data lead to smarter solutions, improved efficiency, and meaningful societal contributions.

3 Program Mission Statement

The mission of a BS Data Science program is to equip students with the technical expertise, analytical mindset, and ethical foundation needed to extract meaningful insights from data. Through a comprehensive curriculum integrating statistics, machine learning, programming, and big data technologies, the program aims to develop problem-solvers who can tackle real-world challenges across various industries. Emphasizing hands-on learning, research, and industry collaboration, the program fosters innovation, critical thinking, and responsible data-driven decision-making. By preparing skilled data professionals, the mission is to contribute to advancements in science, business, healthcare, and technology, ultimately driving progress in a data-driven world.

4 Program Objectives

BS Data science is shaping the latest trends in data, changing how we live, learn, work, and connect. Advances in data science and computing have created new systems in business, manufacturing, communication, research, education, and social interactions. These technologies help with global communication, learning, and databased insights while also driving economic growth. When creating new curricula, the following key objectives should be considered. Some of the key objectives of the program are listed below:

- To develop a strong understanding of the core concepts, theories, and methodologies in data science. Gain proficiency in mathematics, statistics, and computer science as they apply to data

analysis and modeling.

- To learn to collect, clean, and preprocess data from various sources. Develop the ability to analyze and interpret data using statistical and computational techniques. Understand how to identify patterns, trends, and insights from structured and unstructured data.

- To acquire proficiency in programming languages commonly used in data science, such as Python, R, SQL, and others. Learn to use data science tools and frameworks (e.g., Tensorflow, PyTorch, Hadoop, and Spark) for data manipulation, analysis, and visualization.

- To understand the ability to create clear and effective visualizations to communicate data-driven insights. Learn to present complex findings to both technical and non-technical audiences. Gain experience with visualization tools like Tableau, Power BI, and Matplotlib.

5 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 Artificial Intelligence program.

5.1 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.

5.2 Knowledge Areas in ACM CS Curriculum

Sr. #	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, Introduction to 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	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			

6 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.

7 Curriculum Model for Bachelor of Science in Data Science

The generic structure for computing degree program given before is mapped with the BS Artificial Intelligence 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
Allied Courses	15	5
General Education Requirement	32	13
Internship	3	1
Totals	**135**	**46**

Mapping of BS Data Science Program on the Generic Structure:

Sr. #	Code	Pre-Requisite	Course Title	Domain	Credit Hours
Computing Core (46/135) 14 Courses					
1.	COMP1112		Programming Fundamentals	Core	4 (3+1)
2.	COMP2111	Programming Fundamentals (COMP1112)	Object Oriented Programming	Core	4 (3+1)
3.	COMP2114		Database Systems	Core	4 (3+1)
4.	PHYS4129		Digital Logic and Design	Core	3 (2+1)
5.	COMP2117	Programming Fundamentals (COMP1112)	Data Structures	Core	4 (3+1)
6.	COMP2120		Information Security	Core	3 (2+1)
7.	COMP2121		Artificial Intelligence	Core	3 (2+1)
8.	COMP2119		Computer Networks	Core	3 (2+1)
9.	COMP2112		Software Engineering	Core	3 (3+0)
10.	COMP2118		Computer Organization and Assembly Language	Core	3 (2+1)
11.	COMP3142		Operating Systems	Core	3 (2+1)
12.	COMP4121	Data Structures (COMP2117)	Analysis of Algorithms	Core	3 (3+0)
13.	COMPXXXX		Final Year Project – I	Core	3 (0+3)
14.	COMPXXXX	Final Year Project - I (COMPXXXX)	Final Year Project – II	Core	3 (0+3)
Domain Core (18/135) 6 Courses					
15.	COMPXXXX		Introduction to Data Science	Domain Core	3(2+1)
16.	MATHXXXX		Advanced Statistics	Domain Core	3(2+1)
17.	COMP3116		Data Mining	Domain Core	3(3+0)

18.	COMPXXXX		Data Visualization	Domain Core	3(2+1)
19.	COMPXXXX		Data Warehousing &Business Intelligence	Domain Core	3(2+1)
20.	COMP4122		Parallel & Distributed Computing	Domain Core	3(2+1)
Domain Elective (21/135) 7 Courses					
21.	COMP3146		Advanced Database Management Systems	Domain Elective	3(2+1)
22.	COMPXXXX		Big Data Analytics	Domain Elective	3(2+1))
23.	COMP3124		Introduction to Machine Learning	Domain Elective	3(3+0)
24.	COMP3148		Theory of Automata	Domain Elective	3(3+0)
25.	COMP4123		Cloud Computing	Domain Elective	3 (2+1)
26.	COMPXXXX		Advanced Programming Techniques For data science	Domain Elective	3(2+1)
27.	COMP3145		HCI & Computer Graphics	Domain Elective	3(2+1)
Allied Courses (15/135) 5 Courses					
28.	MATH3122		Multivariable Calculus	Allied	3(3+0)
29.	MATH3114		Linear Algebra	Allied	3(3+0)
30.	STAT2115		Introduction to Statistics	Allied	3(3+0)
31.	ITEC4152		Technical & Business Writing	Allied	3(3+0)
32.	BUSA1113		Fundamentals of Accounting	Allied	3(3+0)
General Education Requirement as per HEC UG Education Policy (32/135) 13 Courses					
33.	COMP1116		Application of Information & Communication Technologies	GER	3(2+1)
34.	ENGL1114		Functional English	GER	3(3+0)
35.	ENGL1120		Expository Writing	GER	3(3+0)
36.	MATH2113		Quantitative Reasoning–1(Discrete Mathematics)	GER	3(3+0)
37.	MATH1129		Quantitative Reasoning–2(Calculus and Analytic Geometry)	GER	3(3+0)
38.	ISLA1111/HUMN1111		Islamic Studies/Ethics	GER	2(2+0)
39.	PAKS1119		Ideology and Constitution of Pakistan	GER	2(2+0)
40.	BUSA2118		Social Sciences (Example: Foundations of Management)	GER	2(2+0)
41.	PHYS1124		Natural Sciences (Applied Physics)	GER	3(2+1)
42.	ITEC4112		Arts & Humanities (Professional Practices)	GER	2(2+0)
43.	POLS2111		Civics and Community Engagement	GER	2(2+0)
44.	BUSA1114		Introduction to Entrepreneurship	GER	2(2+0)
45.	PAKS1111		Pakistan Studies	GER	(2+0)

8 List of Courses for other disciplines to take Data Science as Minor

Sr.#	Code	Pre-requisite	Course Title	Credit Hours
1.	COMP1112		Programming Fundamentals	4(3+1)
2.	COMPXXXX		Introduction to Data Science	3(2+1)
3.	COMP2114		Database Systems	4(3+1)
4.	STAT2115		Introduction to Statistics	3(3+0)
5.	COMP3116		Data Mining	3(3+0)
6.	COMPXXXX		Data Visualization	3(2+1)
7.	MATHXXXX		Advanced Statistics	3(2+1)
8.	COMP4122		Parallel & Distributed Computing	3(2+1)
9.	COMP3124		Introduction to Machine Learning	3(3+0)
10.	COMP2121		Artificial Intelligence	3(2+1)

Note: (Foundations of Mathematics / Equivalent). Course are applicable only to individuals who have not previously studied (FSc) mathematics in their prior degree. Additionally, courses will be considered as non-credited courses.

9 Semester/Study Plan for BS Data Science

Course codes will be assigned based on the codes generated in the University of Education Lahore Information System (UE, Lahore). The course codes for the remaining courses will be generated after approval from the Academic Council.

Semester – I					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
1.	COMP1112		Programming Fundamentals	Core	4(3+1)
2.	COMP1116		Applications of Information and Communication Technologies	GER	3(2+1)
3.	MATH2113		QR 1 (Discrete Mathematics)	GER	3(3+0)
4.	ENGL1114		Functional English	GER	3(3+0)
5.	PHYS1124		Applied Physics	GER	3(2+1)
6.	ISLA1111/ HUMN1111		Islamic Studies / Ethics	GER	2(2+0)
	MATH1127		Pre-Calculus-I (Only for Pre-Medical Students)		Non-Credited
		Total (GER + Core = 14+4=18)			**18(15+3)**
Semester – II					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
7.	COMP2111	Programming Fundamentals (COMP1112)	Object Oriented Programming	Core	4(3+1)
8.	MATH3114		Linear Algebra	Allied	3(3+0)
9.	ENGL1120		Expository Writing	GER	3(3+0)
10.	COMP2119		Computer Networks	Core	3(2+1)
11.	PAKS1119		Ideology and Constitution of Pakistan	GER	2 (2+0)
12.	PHYS4129		Digital Logic and Design	Core	3(2+1)
	ISLA1120/ ISLA1121		ترجمہ قران کورس/دحدت ادیان اور مذاہب عالم		Non-Credited
	MATH1128		Pre-Calculus-II (Only for Pre-Medical Students)		Non-Credited
		Total (GER + Core=8+10=18)			**18(15+3)**

Semester – III					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
13.	ITEC4112		Professional Practices	GER	2(2+0)
14.	COMP2117	Programming Fundamentals (COMP1112)	Data Structures	Core	4(3+1)
15.	COMP2118		Computer Organization and Assembly Language	Core	3 (2+1)
16.	BUSA2118		Foundations of Management	GER	2 (2+0)
17.	MATH1129		Calculus and Analytic Geometry	GER	3(3+0)
18.	COMP2114		Database Systems	Core	4(3+1)
		Total (GER + Core + Allied= 4+11+3=18)			**18(15+3)**
Semester – IV					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
19.	BUSA1114		Introduction to Entrepreneurship	GER	2(2+0)
20.	POLS2111		Civics and Community Engagement	GER	2(2+0)
21.	COMP2120		Information Security	Core	3(2+1)
22.	COMP2121		Artificial Intelligence	Core	3(2+1)
23.	MATH3122		Multivariable Calculus	Allied	3(3+0)
24.	COMP2112		Software Engineering	Core	3(3+0)
25.	PAKS1111		Pakistan Studies	GER	2 (2+0)
	ISLA1120/ ISLA1121		ترجمہ قران کورس/دحدت ادیان اور مزاہب عالم		Non-Credited
		Total (GER + Core + Allied = 6 + 9 + 3 = 18)			**18(16+2)**

Semester – V					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
26.	COMP3142		Operating Systems	Core	3(2+1)
27.	COMPXXXX		Domain Core 1(Introduction to Data Science)	Domain Core	3(2+1)
28.	STAT2115		Introduction to Statistics	Allied	3(3+0)
29.	COMPXXXX		Domain Core 2 (Data Warehousing & Business Intelligence)	Domain Core	3(2+1)
30.	COMPXXX		Domain Elective 1	Domain Elective	3(3+0)
31.	COMPXXX		Domain Elective 2	Domain Elective	3(2+1)
		Total (Core + Domain Core + Domain Elective + Allied= 2 + 3 + 6+6=17)			**18 (14+4)**
Semester – VI					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
32.	COMP4121	Data Structures (COMP2117)	Analysis of Algorithms	Core	3(3+0)
33.	MATHXXXX		Domain Core 3 (Advanced Statistics)	Domain Core	3(2+1)
34.	COMPXXXX		Domain Elective 3	Domain Elective	3(3+0)
35.	COMPXXXX		Domain Elective 4	Domain Elective	3(2+1)
36.	COMPXXXX		Domain Elective 5	Domain Elective	3(2+1)
37.	COMP3116		Domain Core 4 (Data Mining)	Domain Core	3(2+1)
	ISLA1120/ ISLA1121		ترجمہ قران کورس/دحدت ادیان اور مزاہب عالم		Non-Credit
		Total			**18(14+4)**

Semester – VII					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
38.	COMPXXXX		Final Year Project- I	Core	3(0+3)
39.	COMPXXXX		Domain Core 5 (Data Visualization)	Domain Core	3(2+1)
40.	COMPXXX		Domain Elective 6	Domain Elective	3(2+1)
41.	COMPXXX		Domain Elective 7	Domain Elective	3(3+0)
42.	INTN6112		Internship		3(0+3)
43.	ITEC4152		Technical & Business Writing	Allied	3(3+0)
	Total				**18(7+8)**
Semester – VIII					
Sr #	**Code**	**Prerequisite**	**Course Title**	**Domain**	**Credit Hours**
44.	COMPXXXX		Final Year Project–II	Core	3(0+3)
45.	BUSA1113		Fundamentals of Accounting	Allied	3(3+0)
46.	COMP4122		Domain Core 6 (Parallel & Distributed Computing)	Domain Core	3(2+1)
	ISLA1120/ ISLA1121		ترجمہ قران کورس/دحدت ادیان اور مزاہب عالم		Non-Credited
		Total			**09(6+3)**

The Internship of six to eight weeks is mandatory requirement for the award of degree. Students will take an Internship 3(0+3) course during summer vacations after sixth semester, and the result of this course will be added in the seventh semester.

Note: One credit of lab means 3 contact hours, which means students will spend three hours in the lab for each credit earned.

University Mandatory Courses (Non-Credited)

Sr. #	Course Code	Course Title	Credit Hours
1	**ISLA1121/ *ISLA1120	ترجمہ قران کورس/دحدت ادیان اور مزاہب عالم	4(4+0)
2	***ISLA1122	Seerat of the Holy Prophet Muhammad (SAW)	2(2+0)

*For non-Muslim Students only

**The courses will be evaluated in (8th semester) and taught in 2nd, 4th, 6th, and 8th semester. Course outline approved in the Notification No. UE/Syn/DD/2020/2158 Dated: December 31, 2020 will be followed.

*** The course **"Seerat of the Holy Prophet Muhammad (SAW)-ISLA1122**" bearing course code ISLA1122 with 2(2+0) Credit Hours is compulsory. Its lectures will be recorded in digital form and available to all students. Students may study (online) this course in any semester and will be examined online too. This course will be considered as Non-Credited.

10 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 BS Artificial Intelligence Program.
- **Equivalency certificate by IBCC will be required in case of education from some other country or system.*
- FSc pre-medical students are also eligible but the students have to pass deficiency course Pre-Calculus I and Pre-Calculus II. Additionally, the course will be considered as non-credited course.
- At minimum **135** credit hours are required for award of BS Data Science degree.
- The minimum duration for completion of BS Data Science degree is four years. The maximum period of degree completion will be followed as per University of Education Lahore policy.
- A minimum 2.0 CGPA (Cumulative Grade Point Average) on a scale of 4.0 is required for award of BS Data Science Degree.
- After successfully completing 04 semesters in the BS Data Science program, students may exit with an Associate Degree in BS Data Science program, subject to meeting all requirements for the award of the associate degree. These requirements include fulfilling the required Credit Hours, achieving a minimum CGPA, and completing compulsory courses or as per the approved university policy. However, students must complete a minimum of 72 credits to be eligible for the Associate Degree.

Note: The Internship of six to eight weeks is mandatory requirement for the award of degree.

- Department offers the following options of minor/major from the available subjects at University of Education, Lahore subject to the approval of the concerned statutory body upon recommendation of the concerned department.
    1. **Single Major**
    2. **Single Major with one Minor**
    3. **Single Major with two Minor**
    4. **Double Major***

  *Additional semester(s) will be required to complete the degree requirements in case two majors are offered provided that the total duration to complete the undergraduate/ equivalent degree program does not go beyond the maximum duration prescribed in HEC semester guidelines. Where two majors have common courses, a student can get exemption for maximum of 30 credit hours for the second major.

11 Course Outlines

Course Name:	**Programming Fundamentals**
Course Code:	COMP1112
Credit Hours:	4 (3+1)
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 type sand variables, input/output constructs, arithmetic, compare is on 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 , 4thEdition,TonyGaddis,
2. TheCProgrammingLanguage,2nd Edition by Brian W. Kernighan ,Dennis M.Ritchie
3. Object Oriented Programming in C++by Robert Lafore
4. C how to Program, 7thEditionbyPaulDeitel&HarveyDeitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Course Name: **Object Oriented Programming**
Course Code: COMP2111
Credit Hours: 4 (3+1)
Contact Hours: 3+1
Pre-requisites:

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,accessmodifiers,constvsnon-constfunctions,staticdatamembers & 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***
Course Code: COMP2117
Credit Hours: 4 (3+1)
Contact Hours: 3+1
Pre-requisites: Programming Fundamentals (COMP1112)

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

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

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

Reference Materials: (or use any other standard and latest books)
1. Data Structures and Algorithm Analysis in Java by Mark A. Weiss
2. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
3. Data Structures and Algorithms in C++ by Adam Drozdek
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss
5. Java Software Structures: Designing and Using Data Structures by John Lewis and Joseph Chase

Course Name: ***Digital Logic and Design***
Course Code: PHYS4129
Credit Hours: 3 (2+1)
Pre-requisites: None

Objectives:
The students will be able to understand:

- Digital circuits using Boolean algebra and to implement digital circuits with different logic gates and capable of designing both sequential and combinational circuits for microprocessor based systems.
- Design considerations for the telecommunication systems using analog integrated circuits.

Course Outline:

Review of Number Systems: Binary, octal and hexadecimal number system their inter conversion, basic logic gates, different codes (BCD, ASCII, Gray etc.), Parity in codes.
Boolean Algebra: Demorgan theorems, simplification of Boolean expression by Boolean postulates and theorem, SOP and POS conversions, K maps and their uses, don't carecondition.
Combinational Logic Circuit: Logic circuits based on AND-OR, OR-AND, NAND, NOR Logic gates design, addition, subtraction, 2's compliments, half adder, full adder, half subtractor, full subtractor in coder, decoder, multiplexer and demultiplexer.
Sequential Logic Circuit: Latches, Flip- flop, S-R, J-K, T and D flip flops, Master- slave flips- flops.
IC Logic Families: Basic characteristics of a logic family. (Propagation delay time, dissipation, noise margins etc. Different logic based IC families (DTL, RTL, TTL, CMOS).

List of Experiments

1. To construct and understand an operation of arithmetic logic unit and study different operation of it.
2. Design and study the application of operational amplifier (current to voltageconverter, voltage clamp, integrator and differentiator)

Recommended Books:

1. Nashelsky, L. (1972). *Introduction to digital computer technology*.
2. Debenham, M. J. (2013). *Microprocessors: principles and applications*. Elsevier.
3. Mano, M. M. (1988). *Computer engineering hardware design*. Prentice-Hall, Inc.
4. Tokheim, R. (2007). *Digital Electronics*. 7th Ed McGraw Hill. Instructor of respective course may add two books.

Course Name: *Computer Organization and Assembly Language*
Course Code: COMP2118
Credit Hours: 3 (2+1)
Pre-requisites:

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: *Operating Systems*
Course Code: COMP3142
Credit Hours: 3 (2+1)
Pre-requisites:

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

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

Course Name: ***Database Systems***
Course Code: COMP2114
Credit Hours: 4 (3+1)
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***
Course Code: COMP2120
Credit Hours: 3 (2+1)
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, 6 th edition by M. Whitman and H. Mattord
3. Computer Security, 3 rd edition by Dieter Gollmann
4. Computer Security Fundamentals, 3rd edition by William Easttom 5. Official (ISC)2 Guide to the CISSP CBK, 3 rd edition

Course Name: *Computer Networks*
Course Code: COMP2119
Credit Hours: 3 (2+1)
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, 6 th edition by James F. Kurose and Keith W. Ross
2. Computer Networks, 5 th 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***
Course Code:	COMP2112
Credit Hours:	3 (3+0)
Contact Hours:	3+0
Pre-requisites:	None

Course Introduction:
Introduction to engineering concepts, software engineering concepts including requirements engineering, software process models, process improvement, software architecture, software project planning, cost estimation, software testing, and quality assurance.

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., 8 th Edition, McGraw-Hill, 2015..

Course Name: *Analysis of Algorithms*
Course Code: COMP4121
Credit Hours: 3 (3+0)
Pre-requisites: Data Structures (COMP2117)

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-andconquer, 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*
Course Code: COMP2121
Credit Hours: 3 (2+1)
Pre-requisites:

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, Minmax 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 & Distributed Computing**
COMP4122
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
Pre-requisites: **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 open MP.	

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 ,Open Stack, Cilk, gdb, thre ads ,MPICH ,Open MP, Ha doop, FUSE).

Reference Materials:

1. Distributed Systems: Principles and Paradigms, A.S. Tanenbaumand 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, Improperintegral,ApplicationsofIntegration;Areaunderthecurve,AnalyticalGeometry;StraightlinesinR3, 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; MichaelOlinick; DennisPence; JefferyA.Cole

Course Name: **Linear Algebra**
MATH3114
Credit Hours: **3 (3+0)**
Pre requisites **CAC**
Course Introduction:
To provide fundamentals of solution for system of line are 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

Course Name: **Introduction to Statistics**
Credit Hours: **3(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 **BloomT axonomy**
- - -

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 Makingin Testing Hypotheses (Single Sample & One-and Two Sample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least 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
2. H.Myers, SharonL. Myersand KeyingE.Ye, Pearson;9th Edition (January6, 2011). ISBN-10: 0321629116
3. Probability and Statistics for Engineers and Scientists by AnthonyJ Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10:0495107573
4. Schaum's Outline of Probability and Statistics, by JohnSchiller,R. AluSriniv as an 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,5thEdition.
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 in stances 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. Presentations kills; 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, CollenVawdrey,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,5thEdition.
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 the mtothe 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 rategy, 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
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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.	

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 Laws of Crimes, By Mr Waliullah, Islamic Books Services

Course Name: Ideology and Constitution of Pakistan
Course Code: PAKS1119
Credit 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 thev ariouspillar 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; AllamaIqbal: Independence Movement; Lahore Resolution; Pakistan culture and society, Constitutional and Administrative issues, Pakistan 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, ChaudaryM.,1967
2. The making of Pakistan, Aziz.1976
3. A Short History of Pakistan, I.H.Qureshi,ed.,Karachi,1988

Course Name: **Professional Practices**
ITEC4112
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. ProfessionalIssuesinSoftwareEngineeringbyFrankBott,AllisonColeman,JackEaton and Diane Rowland, CRC Press; 3rd Edition (2000). ISBN-10: 0748409513
2. ComputerEthicsbyDeborahG.Johnson,Pearson;4thEdition(January3,2009).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. AppliedProfessionalEthicsbyGregoryR.Beabout,UniversityPressofAmerica(1993). ISBN-10:0819193747.

Course Name: **Applied Physics**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
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 an 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- Savartlaw, 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, Totalinternal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wavetheory,relatedproblems,Single-SlitDiffraction,relatedproblems,Polarization of electromagnetic waves, Polarizing sheets, related problems.

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

1. Fundamentals of Physics(Extended),10thedition,ResnickandWalker
2. NarcisoGarcia,ArthurDamask,StevenSchwarz.,"PhysicsforComputerScience Students", Springer Verlag, 1998.

Course Name: **Introduction to Information and Communication Technologies**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
Pre-requisites: **None**

Course Introduction:

This is an introductory course in Computer Science designed for beginners. Apart from leading the participants through a whirl wind 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,BackupSystem,DataCommunications,DataCommunicationModel,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,andColinLatchem."Exploringfourdecadesofresearchin Computers & Education." Computers & Education 122 (2018): 136-152.
4.Sinha,PradeepK.,andPritiSinha. Computer fundamentals. BPB publications, 2010.
5.Goel,Anita.Computerfundamentals.PearsonEducationIndia, 2010.

Course Name: **Introduction to Machine Learning**
Credit Hours: **3(3+0)**
Contact Hours: **3+0**
Pre-requisites:

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.	C2 (Apply)
CLO-3	Apply unsupervised learning techniques to solve clustering problems of moderate complexity	C3(Apply)
CLO-4	Apply rein for cement learning algorithms to environments with complex dynamics.	C4(Apply)
CLO-5	Develop are as on able 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, Over fitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical A glomerative 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, MarkovDecisionProcesses;EnsembleLearning:Usingcommitteesofmultiplehypotheses. Bagging, boosting.

Reference Materials:

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

Course Name: ***Theory of Automata***
Course Code: COMP3148

Credit Hours: 3 (3+0)
Pre-requisites: None

Course Introduction:
The course introduces some fundamental concepts in automata theory and formal languages including Grammar, Finite automaton, Regular Expressions, Pushdown automaton, and Turing machine. Theory of Automata and Formal Languages not only the basic models of computation but also the foundation of many branches of computer science, e.g. compilers, software engineering etc.

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: ***Cloud Computing***
Course Code: COMP4123
Credit Hours: 3 (2+1)
Pre-requisites: None

Course Introduction:
The overall aim of this module is to introduce students to the theory, practice, and advance techniques associated with implementing large-scale distributed computing systems in Service-Oriented Architectures (SOA).

CLO No. Course Learning Outcomes	Bloom Taxonomy
CLO-1 Explain the core issues of cloud computing such as security, privacy, consistency and interoperability	C1(Describe)
CLO-2 Develop and deploy cloud application using popular cloud Platforms	C3(Apply)
CLO-3 Compare the key trade-offs between multiple design approaches used for cloud systems.	C3(Compare)

Course Outline:
Introduction to cloud computing, Cloud benefits and challenges, Cloud service providers and cloud ecosystem. Concurrency in the cloud, Parallel and distributed systems , Cloud access and cloud interconnection networks , Cloud data storage , Cloud applications , Cloud hardware , Cloud software , Cloud resource management and scheduling ,Cloud security ,Privacy and compliance issues ,Portability and interoperability issues , Big Data, Data streaming and Mobile cloud.

Reference Materials:
1. Cloud Computing: Theory and Practice, Dan C. Marinescu, latest Edition, Morgan Kaufmann.
Cloud Computing, Sandeep Bhowmik, Cambridge University Press, latest edition

Course Name: Advanced Programming Techniques for Data Science
Course Code: COMPxxxx
Credit Hours: 3 (2+1)
Pre-requisites:

Course Introduction:
The course covers the techniques of Python Programming, application in the domain of data science

CLO No.	Course Learning Outcomes	Bloom Taxonomy
CLO-1	Use the different python libraries of a programming language as Building blocks to develop correct, coherent programs.	C1(Discuss)
CLO-2	Program using the fundamental Programing development process, including design, coding, documentation, testing, and debugging for data science	C3(Develop)
CLO-3	Analyze problems, develop conceptual designs that solve those problems, and transform those designs to Visual Concepts.	C4(Analyze)

Course Outline:

Introduction to Python, covering Python's history, features, and installation, followed by a basic overview of syntax, variables, and data types. Next, Control Flow and Loops should be introduced, explaining conditional statements (if, elif, else) and looping constructs (for, while), along with iteration techniques. The course should then cover Functions and Modules, discussing function definition, arguments, return values, and the use of built-in and user-defined modules to promote code reuse.
Data Structures in Python, including lists, tuples, dictionaries, and sets, with practical applications and manipulation techniques. The next module should focus on File Handling, teaching how to read from and write to files, handle different file formats, and use exception handling to manage errors. This naturally leads to Object-Oriented Programming (OOP) in Python, introducing concepts like classes, objects, inheritance, polymorphism, and encapsulation.
Advanced Python Concepts, such as decorators, generators, list comprehensions, and lambda functions, to enhance efficiency and coding practices. Working with Libraries and Frameworks should introduce essential libraries like NumPy and Pandas for data manipulation, Matplotlib for visualization and class mini project

Reference Materials:

1 Best for learning Python: Automate the Boring Stuff with Python, 3rd Edition 3rd Edition by Al Sweigart https://amzn.to/3B8zHTV (Great for learning the programming language Python).

2. VanderPlas, Jake. Python data science handbook: Essential tools for working with data. " O'Reilly Media, Inc.", 2016.

3. Rogel-Salazar, Jesus. Data science and analytics with Python. Chapman and Hall/CRC, 2018.

Course Name: ***HCI & Computer Graphics***
Course Code: COMP3145
Credit Hours: 3 (2+1)
Pre-requisites: None

Course Introduction:

This course introduces the fundamental concepts of human computer interaction and computer graphics. It describes the implications of human understanding on the usability of computer systems and the importance of understanding the context of use. This course will also develop design and problem solving skills with applications to computer graphics.

CLO No. Course Learning Outcomes	Bloom Taxonomy
CLO-1 Describe the concepts of human understanding on the usability of computer systems and the importance of understanding the context of use.	C2 (Describe)
CLO-2 Explain the basic principles of implementing computer graphics Fundamentals	C2 (Explain)
CLO-3 Analyze and identify usability issues in User interfaces according to the standards.	C4 (Analysis)
CLO-4 Develop the design and problem solving skills with applications to computer graphics	C3(Develop)
CLO-5 Construct interactive computer graphics programs	C3 (Apply)

Course Outline:
The Human: Input-output channels, Human memory, Thinking, Reasoning, Problem solving, Emotions, Individual differences, Psychology and design of interacting systems. The Computer: Introduction, Text entry devices, Positioning, Pointing, and drawing, Display devices, Devices for virtual reality and 3D interaction, Physical controls, Sensors and special devices, Paper printing and scanning, Memory, Processing and networks. The Interaction: Models of interaction, Frameworks and HCI, Ergonomics, Interaction styles, Elements of the WIMP interfaces, Interactivity, Context of interaction, Experience. Usability Paradigm and Principles: Introduction, Paradigms for interaction. Interaction Design Basics: Introduction, What is design, Process of design, User focus, Navigation design, Screen design and layout, Iteration and prototyping. HCI in Software Process: Introduction, Software life cycle, Usability engineering, Iterative design and prototyping, Design rationale. Design rules, Prototyping, Evaluation techniques, Task analysis, Universal design and User support and Computer Supported Cooperative Work: Guidelines, Golden rules and heuristics, HCI patterns, Choosing an evaluation method, Requirements of user support, Applications, Design user support systems. Introduction to Groupware, Pervasive and Ubiquitous Applications: Introduction, Groupware systems, Implementation of synchronous groupware, Ubiquitous computing. History of Computer Graphics, Graphics architectures and software, Imaging, Pinhole camera, Human vision, Synthetic camera, Modeling vs. rendering. OpenGL: Architecture, Displaying simple two-dimensional geometric objects, Positioning systems, Working in a windowed environment. Color: Color perception, color models (RGB, CMY, HLS), color transformations. Color in OpenGL. RGB and indexed color rotation, scaling, shear), homogeneous coordinates, concatenation, current transformation and matrix stacks. Three Dimensional

Graphics: Classical three dimensional viewing, Specifying views, Affine transformation in 3D, Projective transformations. Ray tracing. Shading: Illumination and surface modeling, Phong shading model, Polygon shading. Rasterization: Line drawing via Bresenham's algorithm, clipping, polygonal fill, BitBlt. Introduction to hidden surface removal (z buffer). Discrete Techniques: Buffers, reading and writing bitmaps and pixel maps, texture mapping, compositing.

Reference Materials:

1. Janet E. Finlay, Leeds Metropolitan. (2000). Human-Computer Interaction, Alan Dix, Computing Dept, Lancaster University, Birmingham Publisher: PrenticeHall.
2. Ben Shneiderman, University of Maryland Catherine Plaisant. (2010). Designing the User Interface: Strategies for Effective Human-Computer Interaction, 4/E, University Maryland. Publisher: Addison-Wesley.
3. Computer Graphics with Open GL (4th Edition) by Donald D. Hearn, Prentice Hall, 2010, ISBN-10: 0136053580.
4. Foundations of 3D Computer Graphics by S. J. Gortler, The MIT press, 2012.
5. Fundamentals of Computer Graphics, 3rd Edition, A K Peters, 2009.
6. Computer Graphics: Principles and Practice, 3rd Edition

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	
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, Over dispersion 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+1)**
Contact Hours: **2+1**
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.	C1(Understand)
CLO-2	Hadoop /Map Reduce Programming, Framework, and Ecosystem	
CLO-3	ApacheSpark 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), Map Reduce Framework, Resource Management in the cluster(YARN), Apache Scala Basic ,Apache Scala Advances, Resilient Distributed Datasets(RDD), Apache Spark ,Apache Spark SQL ,Data analyticson Hadoop / Spark, Machine learning on Hadoop / Spark, Spark Streaming, Other Components of Hadoop Ecosystem

Reference Materials:

1. White,Tom. “Hadoop:Thedefinitiveguide."O'ReillyMedia, Inc.,2012.
2. Karau,Holden,AndyKonwinski,PatrickWendell,andMateiZaharia.“Learning spark: lightning-fast big data analysis." O'Reilly Media, Inc., 2015.
3. Miner, Donald, andAdamShook.“MapReduce design patterns: building effective algorithmsandanalyticsforHadoopandothersystems."O'ReillyMedia,Inc.,2012.

Course Name: **Data Mining**

Credit Hours: **3(3+0)**
Contact Hours: **3+0**
Pre-requisites:

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.	C1(Apply)
CLO-2	Select and apply proper data mining algorithm to discover interesting patterns	
CLO-3	Analyze and extract patterns to solve problems and point out how to deploy solution	C3 (Analyze)
CLO-4	Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect 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-NingTan,Michael Steinbach, and VipinKumar(2005).Introduction to Data Mining.
3.CharuC. Aggarwal(2015).Data Mining: The Textbook
4.D.Hand, H.Mannila,P. Smyth(2001).Principles of Data Mining. MITPress.

Course Name: **Data Visualization**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
Pre-requisites:

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 interms 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
CLO-2 Introduce various type of charts along with their alternatives solution to show same data from versatile aspects.
CLO-3 Improving the competency of the students to analyze different problems and select the most appropriate solution.
CLO-4 Use of R, various recent tools, and technologies to develophands-on skills for exploratory data analysis and visualization.

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, pare to; 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”byRogerD.Peng

Course Name: **Data Warehousing & Business Intelligence**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
Pre-requisites:

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	C1(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 base don these two models.	C2(Understand)
CLO-3	Undersand the architecture of DW Systems and be able to specify the advantages and potential problem areas	C3(Understand)
CLO-4	Use Analytic SQL to aggregate ,analyze and report ,and model data.	C4(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 Data warehouse 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. RalphKimball,“TheDataWarehouseToolkit–PracticalTechniquesforBuilding Dimensional Data

Warehouse," John Wiley & Sons, Inc.
3. MatteoGolfarelli,StefanoRizzi,"DataWarehouseDesign-ModernPrinciplesand Methodologies",McGrawHillPublisher

Course Name: **Introduction to Data Science**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
Pre-requisites:
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, database sand 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 processing a case study	C3 (Apply)
CLO-3 Comprehend the fundamental constructs of Python programming language.	
CLO-4 Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C4 (Apply)

Course Outline:

Introduction: What is Data Science? Big Data and Data Science type ,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.,Vorabversioneines 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'Neiland 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: **Advance Database Management Systems**
Credit Hours: **3(2+1)**
Contact Hours: **2+1**
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, MONGODB, 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. DatabaseManagementSystems,3rd Edition by Raghu Ramakrishnan, Johannes Gehrke
3. DatabaseSystemConcepts,6th Edition by Avi Silberschatz, Henry F. Korthand S. Sudarshan.
4. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina,Jeffrey D.Ullman,JenniferWidom

Course Name: ***Pre-Calculus-I***
Course Code: MATH1127
Credit Hours: 3 (3+0)
Pre-requisites:

Aims & Objectives:
This subject develops the concepts of Mathematics and its applications in daily life. The students are taught different mechanisms as well as issues at different levels are discussed.

Course Content:

Introduction of Mathematics

History, Applications of mathematics, Number systems

SETS and Functions

Set, All type of sets, Operations on sets, Complex Numbers and its methods of simplification, Polar form of complex number, Functions and their types, Inverse of function, Graphs, Relevant Problems and their solutions

Matrices and Determinants

Matrix, all types of matrices, Operations on matrices, Determinants of 2 x 2 and 3 x 3 matrix, Solution of simultaneous linear equations by using matrices, Elementary Row and Column operation on a matrix, Echelon and Reduced Echelon forms of Matrices, System of Linear equations, Homogeneous Linear equation, Cramer‟ s rule, Relevant Problems and their solutions

Quadratic Equations

Introduction, Solution of Quadratic Equations, Polynomial Function, Remainder Theorem and its applications, Relevant Problems and their solutions

Partial Fractions

Rational fraction, Proper rational fraction, Improper rational fraction, Resolution of all types of fraction, Relevant Problems and their solutions

Mathematical Induction and Binomial Theorem

Binomial theorem and its application on different types of functions, Relevant Problems and their solutions

Fundamentals of Trigonometry

Introduction, Units of Measures of Angles, Angles in Standard Position, Trigonometric Functions, Trigonometric Functions of any angle, Fundamental Identities of Geometric Functions, Signs of Trigonometric Functions, The value of Trigonometric Functions of Acute Angles 30^0, 45^0 and 60^0, The value of Trigonometric Functions of Angles 0^0, 90^0, 180^0, 270^0, 360^0, Proves of Fundamental Identities

with different types of functions, Half angle Identities, Sum, Difference and product of Sines and Cosines, Period of Trigonometric Functions, Relevant Problems and their solutions

Reference Books & Material

Complete solution in PDF form

Recommended Text Book

Thomas Calculus 12th Edition

Course Title: **Pre-Calculus-II**
Course Code: MATH1128
Credit Hours: **3(3+0)**

Aims and Objectives:

This subject develops the concepts of Mathematics and its applications in daily life. The studentsare taught different mechanisms as well as issues at different levels are discussed.\

Course Contents:

Introduction of Mathematics
History, Applications of mathematics

Functions, Limits and Continuity

Definition of Functions, Graph of Algebraic Functions, Polynomial Functions, Linear Function, Identity Function, Constant Function, Rational Function, Explicit Function, Implicit Function, Exponential Function, Logarithmic Function, Trigonometric Functions, Inverse Trigonometric Functions, Parametric form of Function, Even Function, Odd Function, Composition of Functions, Definition of Limit, Limit Theorems, Application of Limit onAlgebraic and Geometric Function, Continuity of a Function, Relevant Problems and their solutions

Differentiation

Independent and Dependent variables, Average rate of change, Derivative and slop, By Definition Derivative, Rules of Derivation, Derivation of Algebraic and Geometric Functions, Taylor' Theorem, Relevant Problems and theirsolutions

Integration

Introduction of Integration, Formulas of Integration, Simple problems related with Integration, Relevant Problems and their solutions

Integration

Integration by parts, Integration by substitution method, Integration involving limit, Area of region bounded by the curve, Relevant Problems and their solutions

Introduction to Analytical Geometry

Quadrants, The Distance Formula, Slop of straight line, Equation of a straight Line, Intercepts form, Translation and Rotation of axes, Relevant Problems and their solutions

Conic Section

Introduction, General form of an Equation of a Circle, Center, Radius and Diameter of a Circle, Relevant Problems and their solutions, The Equation ofa Circle when end points of its diameter are given, Relevant Problems and their solutions

Recommended Textbook:
Howard Anton 10th Edition

UNIVERSITY OF EDUCATION, LAHORE

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March 30, 2025

NOTIFICATION

No.UE/Syn/R/2025/1204 The Syndicate, in its 77th meeting held on 24.02.2026, on the recommendations of the Academic Council made in its 49th meeting held on 01.09.2025, has approved the **New Scheme of Studies** of following Degree Programs:

SN	Nomenclature of the Degree Program	Abbreviation of the Degree Program	Duration	Applicable w.e.f.	Annex
1.	Doctor of Philosophy in Computer Science	PhD Computer Science	3 Years	Fall 2025	'A'
2.	Bachelor of Science in Software Engineering	BS Software Engineering	4 Years	Fall 2025	'B'
3.	Bachelor of Science in Data Science	BS Data Science	4 Years	Fall 2025	'C'
4.	Bachelor of Science in Computer Science	BS Computer Science	4 Years	Fall 2025	'D'
5.	Bachelor of Science in Information Technology	BS Information Technology	4 Years	Fall 2025	'E'

Muhammad Nasir Ahmad
Registrar

No. & Date Even

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2. Pro-Vice Chancellor
3. PA to Registrar
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13. Assistant Directors (Establishment I/II)
14. Office file

Muhammad Nasir Ahmad
Registrar