

UNIVERSITY OF THE PUNJAB

NOTIFICATION

The Vice-Chancellor has, in exercise of the powers vested in him under Section 15(3) of the University of the Punjab Act, 1973 and in anticipation of approval of the Academic Council/Syndicate, been pleased to approve the recommendations of the Boards of Studies in Software Engineering, Information Technology and Computer Science and Board of Faculty of Computing & Information Technology at their meetings held on 10-04-2026, 23-04-2026, 30-04-2026 and 04-06-2026 respectively regarding the launch and approval of the Curriculum for the following Programs to be offered at University of the Punjab and its Affiliated Colleges from Fall 2026 :-

1. BS Computer Science
2. BS Computer Science (Specialization in Information Technology)
3. BS Computer Science (Specialization in Software Engineering)
4. BS Computer Science (Specialization in Artificial Intelligence)
5. Associate Degree in Computing
6. Associate Degree in Computing (Specialization in Information Technology)
7. Associate Degree in Computing (Specialization in Artificial Intelligence)

The Curriculum and Course Syllabi for above mentioned Programs are attached herewith, vide Annexure 'A' to 'G'.

**Admin. Block,
Quaid-i-Azam Campus,
Lahore.
No. D/ 2690 /Acad.**

Sd/-
**Dr. Ahmad Islam
Registrar**

Dated: 10-06-2026.

Copy of the above is forwarded to the following for information and further necessary action: -

1. Pro-Chancellor/The Minister of Education,
Govt. of the Punjab, Lahore.
2. Members of the Syndicate.
3. Dean, Faculty of Computing & Information Technology.
4. Chairman, Department of Computer Science/Software Engineering/
Information Technology
5. Principals of Affiliated Colleges (Concerned)
6. Controller of Examinations
7. Director. Quality Enhancement Cell
8. Director, IT (for Uploading on website)
9. Additional Registrar (Affiliation)
10. Deputy Registrar (General)
11. Secretary to the Vice-Chancellor
12. Secretary to the Pro-Vice-Chancellor
13. Secretary to the Registrar
14. Assistant Registrar (Statutes)
15. Assistant Registrar Syndicate (with file)
16. Assistant Registrar (Syllabus)



**Dr. Ahmad Islam
Registrar**

Curricula, Scheme of Study and Syllabi

Program

BS Computer Science (Specialization in Artificial Intelligence) [BSCS(AI)]

Offered at Affiliated Colleges University of the Punjab

Department of Information Technology
Faculty of Computing & Information Technology

Version: 1.0.6

Date: 08-06-2026

University of the Punjab, Lahore

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1. Introduction

Artificial Intelligence (AI) is revolutionizing the way we live, work, and interact with the world around us. From simplifying daily tasks to transforming industries with sophisticated decision-making systems, AI plays a pivotal role in modern life. The Department of Information Technology (DIT) is committed to providing cutting-edge education and training to equip students with the skills needed to excel in this dynamic field. Our graduates are prepared to compete on both national and international levels, contributing to the advancement of AI and its applications.

2. Vision

To be a globally acclaimed institution, recognized for excellence in education, research, and innovation.

3. Mission

To rigorously train students in the field of Artificial Intelligence and related disciplines, empowering them with the knowledge, skills, and ethical values necessary to serve society and contribute to the advancement of humanity.

4. Program Introduction

The Bachelor of Computer Science Specialization in Artificial Intelligence (BSCS-AI) program at DIT is designed in alignment with the guidelines set forth by the National Computing Education Accreditation Council (NCEAC) under the Higher Education Commission (HEC) of Pakistan. This program focuses on imparting in-depth knowledge and practical skills in AI, preparing students for advanced studies, diverse career opportunities, and entrepreneurial ventures. The curriculum emphasizes innovative learning, ensuring that graduates are well-equipped to meet the demands of the rapidly evolving AI industry.

5. Program Education Objectives (PEOs)

The educational objectives of the BSAI program are as follows:

5.1 PEO1: Technical Proficiency and Innovation

Enable students to design, develop, and deploy AI-based solutions to solve real-world problems. Graduates will exhibit technical expertise by applying theoretical knowledge and practical skills in AI, fostering innovation and enhancing problem-solving through critical and computational thinking. They will be prepared for successful careers in academia, industry, and entrepreneurial endeavors.

5.2 PE02: Collaborative, Ethical, and Professional Responsibility

Instill a strong sense of ethical and professional responsibility in graduates, ensuring they understand the societal implications of AI technologies. Graduates will work collaboratively in interdisciplinary teams, demonstrate leadership, and address ethical, legal, and cultural considerations while adhering to professional standards in their practice.

5.3 PE03: Lifelong Learning and Communication Skills

Cultivate lifelong learning abilities, enabling graduates to stay abreast of emerging AI technologies and tools. Graduates will adapt to evolving challenges, pursue continuous professional growth, and communicate complex ideas effectively through oral and technical mediums. This prepares them for diverse roles in academia, industry, and public service.

6. Program Learning Outcomes (PLOs)

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).

PLO1: Academic Education: To prepare graduates as computing professionals.

PLO2: 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.

PLO3: 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.

PLO4: 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.

PLO5: 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.

PLO6: Individual and Team Work: Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.

PLO7: 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.

PLO8: 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.

PLO9: Ethics: Understand and commit to professional ethics, responsibilities, and norms of professional computing practice.

PLO10: Life-long Learning: Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional.

7. PLO to PEO Mapping

Following is the PEOs to PLOs mapping for BS Information Technology Program

No.	Program Learning Outcomes (PLOs)	PEO-1	PEO-2	PEO-3
1	Academic Education	√		
2	Knowledge for solving Computing Problems	√		
3	Problem Analysis	√		
4	Design/ Development of Solutions	√		
5	Modern Tool Usage	√		
6	Individual and Teamwork		√	√
7	Communication		√	
8	Computing Professionalism and Society		√	
9	Ethics		√	
10	Life-long Learning			√

8. Bloom's Taxonomy for Program Learning Outcomes (PLOs)

Bloom's Taxonomy classifies various outcomes and skills (PLOs) into six levels, as shown in the table below. These levels can be used to structure the learning outcomes, lessons, and assessments of a course. Each level of Bloom's Taxonomy corresponds to one or more PLOs.

Level	Description	Key Words
Remembering	Can the students <u>recall</u> or <u>remember</u> the information?	know, describe, identify, label, list, match, memorize, recall
Understand	Can the students <u>explain</u> ideas or concepts?	classify, describe, cite, discuss, generalize, illustrate, restate (in own words), summarize
Applying	Can the students <u>use</u> the	assess, choose, solve, demonstrate,

	information in a new way?	dramatize, demonstrate, establish, extend, illustrate,
Analyzing	Can the students <u>distinguish</u> between different parts?	analyze, appraise, categorize, compare, identify, contrast, criticize, differentiate, recognize
Creating	Can the students <u>create</u> new product or point of view?	adapt, incorporate, individualize, integrate, intervene, invent, model, modify, communicate, construct, create, design, develop, formulate, generate, reconstruct, reinforce,
Evaluating	Can the students <u>justify</u> a stand or decision?	appraise, argue, choose, compare, conclude, contrast, criticize, interpret, judge, justify, predict, rate

9. Admission Eligibility Criteria

- Higher Secondary School Certificate/A-levels (involving minimum 12 years of schooling) or an IBCC equivalent qualification, with at least 50% marks and having studied Mathematics, is the basic eligibility requirement for admission in all BS Computer Science.
 - The students who have not studied Mathematics at intermediate level have to pass deficiency courses of Mathematics (06 credits) in first year including zero semester.
- Additionally, applicants may be required to pass an entry test conducted by the department, university, or admission authority, along with fulfilling any other criteria set by the institution, such as interviews or aptitude assessments.
- Any other (if applicable)

10. Duration of the Program and Degree Awarding Criteria

The BS Artificial Intelligence program spans 8 semesters over 4 years and requires the completion of 130 credit hours. To qualify for the degree, students must achieve a minimum CGPA of 2.0. Additionally, a final year project is mandatory. Other requirements, such as a comprehensive examination, may apply if specified.

11. Categorization of Courses

13.1 Nomenclature of Course Categories and Course Codes

N	Code	Description	Courses	Cr. Hrs.	
0	MD	Math Deficiency	02*	06*	(06, 0)*
1	CC	Computing Core	22	54	(39, 15)
2,3	EA	Specialization Elective	08	24	(16,8)
5	ID	Interdisciplinary Courses	04	12	(10, 2)
6	GE	General Education Courses (Math & Science)	05	12	(10, 2)
7	GE	General Education Courses (Management & Social Science)	04	08	(8, 0)
9	GE	General Education Courses (Arts & Languages)	07	14	(12, 2)
8	PT	Professional Training	02	06	(3,3)
Total			52	130	(98, 32)

Course Coding Scheme: Code-YCS

Y = Year of Offering (Earliest) = 1, 2, 3, 4

C = Course Category Code = 0, 1, ..., 9

S = Serial Number (Resets with Year) = 0, 1

Lab Codes: Code-YCS-L

13.2 Comparison with HEC/NCEAC Recommendation

Note: Basics courses represent Math and Supporting and General Education courses as per HEC/NCEAC approved curriculum based on HEC Undergraduate Policy 2025.

CC = Computing Core, EA = Specialization Elective (EA), PT= Internship, FYP= Final Year Project, GE = General Education, ID = Interdisciplinary courses, MD = Math Deficiency

Semester	Number of Courses	Category (Credit Hours)									Semester Load
		Discipline Related Courses / Major			Cr. Hrs. (Theory, Lab)	Others				Cr. Hrs. (Theory, Lab)	Cr. Hrs. (Theory, Lab)
		CC	EA	PT		GE	ID	MD	FYP		
1	9	04	0	0	04 (03,1)	14	0	3*	0	14 (11,3)	18 (14,4)
2	7	07	0	0	07 (05,2)	09	0	3*	0	09 (08,1)	16 (13,3)
3	7	11	0	0	11 (08,3)	03	3	0	0	06 (06,0)	17 (14,3)
4	7	14	0	0	14 (11,3)	00	3	0	0	03 (03,0)	17 (14,3)
5	6	09	6	0	15 (13,2)	00	3	0	0	03 (02,1)	18 (15,3)
6	5	03	9	0	12 (09,3)	00	3	0	0	03 (02,1)	15 (11,4)
7	6	00	6	3	09 (07,2)	04	0	0	3	07 (04,3)	16 (11,5)
8	5	00	3	3	06 (02,4)	04	0	0	3	07 (04,3)	13 (06,7)
PU	52	48	24	6	78 (58,20)	34	12	6*	6	52 (40,12)	130 (98,32)
HEC Guidelines	-	48	24	6	78 (58,20)	34	12	6*	6	52 (40,12)	130 (98,32)
Difference HEC & PU	-	0	0	0	0		0	0	0	0	0

* These Math courses will be Non-Credit courses with only Pass/Fail grade assigned to the students.

The courses with lab are counted as 2 separate courses.

13.3 Category-wise List of Courses

COMPUTING CORE: 48 (CC) + 6 (FYP) (39+15)					
Sr.	Sem.	Code	Course Title	Prerequisite	Cr. Hrs.
1	1	CC-110	Digital Logic Design		3 (3,0)
2	1	CC-110-L	Digital Logic Design Lab		1 (0,1)
3	2	CC-113	Computer Networks		2 (2,0)
4	2	CC-113-L	Computer Networks Lab		1 (0,1)
5	2	CC-112	Programming Fundamentals		3 (3,0)
6	2	CC-112-L	Programming Fundamentals Lab		1 (0,1)
7	3	CC-211	Object Oriented Programming	Programming Fundamentals	3 (3,0)
8	3	CC-211-L	Object Oriented Programming Lab	Programming Fundamentals	1 (0,1)
9	3	CC-111	Computer Organization & Architecture	Digital Logic Design	2 (2,0)
10	3	CC-111-L	Computer Organization & Architecture Lab	Digital Logic Design	1 (0,1)
11	3	CC-215	Database Systems		3 (3,0)
12	3	CC-215-L	Database Systems Lab		1 (0,1)
13	4	CC-212	Software Engineering		3 (3,0)
14	4	CC-213	Data Structures	Object Oriented Programming	3 (3,0)
15	4	CC-213-L	Data Structures Lab	Object Oriented Programming	1 (0,1)
16	4	CC-218	Artificial Intelligence	Object Oriented Programming	2 (2,0)
17	4	CC-218-L	Artificial Intelligence Lab	Object Oriented Programming	1 (0,1)
18	4	CC-216	Operating Systems		3 (3,0)
19	4	CC-216-L	Operating Systems Lab		1 (0,1)
20	5	CC-217	Information Security		3 (3,0)
21	5	CC-313	Design and Analysis of Algorithms	Data Structures	3 (3,0)
22	5	CC-219	Theory of Automata		3 (3,0)
23	6	CC-314	Cloud Computing	-	3 (3,0)
24	7	CC-411	Final Year Project – I		3 (0,3)
25	8	CC-412	Final Year Project – II	Final Year Project – I	3 (0,3)

GENERAL EDUCATION: 34 (30, 4)					
Sr.	Sem.	Code	Course Title	Sub-Category	Cr. Hrs.
1	1	GE-160	Applications of Information & Communication Technologies	Math & Science	2 (2,0)
2	1	GE-160-L	Applications of Information & Communication Technologies Lab	Math & Science	1 (0,1)
3	1	GE-169	Applied Physics	Math & Science	3 (2,1)
4	1	GE-196	Islamic Studies	Arts & Languages	2 (2,0)
5	1	GE-194	Pakistan Studies	Arts & Languages	2 (2,0)
6	1	GE-190	Functional English	Arts & Languages	3 (3,0)
7	2	GE-167	Discrete Structures	Math & Science (QR-I)	3 (3,0)
8	2	GE-191	Expository Writing	Arts & Languages	3 (3,0)
9	2	GE-197	Fehm-e-Quran-I	Arts & Languages	1 (0,1)
10	2	GE-198	Fehm-e-Quran-II	Arts & Languages	1 (0,1)
11	2	GE-170	Introduction to Management	Management & Social Sciences	2 (2,0)
12	3	GE-260	Probability and Statistics	Math & Science (QR-II)	3 (3,0)

13	7	GE-271	Entrepreneurship	Management & Social Sciences	2 (2,0)
14	7	GE-270	Professional Practices	Management & Social Sciences	2 (2,0)
15	8	GE-195	Ideology and Constitution of Pakistan	Arts & Languages	2 (2,0)
16	8	GE-272	Civics and Community Management	Management & Social Sciences	2 (2,0)

ARTIFICIAL INTELLIGENCE ELECTIVE: 24 (16, 8) EIGHT COURSES (NON-EXHAUSTIVE/ETENSIBLE LIST OF COURSES)					
Sr.	Sem.	Code	Course Title	Prerequisite	Cr. Hrs
1	5	EA-320	Programming for AI	Artificial Intelligence	2 (2,0)
2	5	EA-320-L	Programming for AI Lab	Artificial Intelligence	1 (0,1)
3	5	EA-321	Machine Learning		2 (2,0)
4	5	EA-321-L	Machine Learning Lab		1 (0,1)
5	6	EA-322	Deep Learning	Programming for AI	2 (2,0)
6	6	EA-322-L	Deep Learning Lab	Programming for AI	1 (0,1)
7	6	EA-323	Knowledge Representation & Reasoning		2 (2,0)
8	6	EA-323-L	Knowledge Representation & Reasoning Lab		1 (0,1)
9	6	EA-324	Game Design and Development	Object Oriented Programming	2 (2,0)
10	6	EA-324-L	Game Design and Development Lab	Object Oriented Programming	1 (0,1)
11	7	EA-325	Computer Vision	Deep Learning	2 (2,0)
12	7	EA-325-L	Computer Vision Lab	Deep Learning	1 (0,1)
13	7	EA-326	Natural Language Processing	Deep Learning	2 (2,0)
14	7	EA-326-L	Natural Language Processing Lab	Deep Learning	1 (0,1)
15	8	EA-421	Agentic Artificial Intelligence	Programming for AI	2 (2,0)
16	8	EA-421-L	Agentic Artificial Intelligence	Programming for AI	1 (0,1)
17	X	EA-328	Generative Artificial Intelligence	Artificial Intelligence	2 (2,0)
18	X	EA-328-L	Generative Artificial Intelligence Lab	Artificial Intelligence	1 (0,1)
19	X	EA-327	Agent Based Modeling		2 (2,0)
20	X	EA-327-L	Agent Based Modeling Lab		1 (0,1)
21	X	EA-422	Reinforcement Learning	Artificial Intelligence	2 (2,0)
22	X	EA-422-L	Reinforcement Learning Lab	Artificial Intelligence	1 (0,1)

Interdisciplinary (Any FOUR): 12 (10, 2)					
Sr.	Sem.	Code	Course Title	Prerequisite	Cr. Hrs
1	3	ID-150	Calculus and Analytical Geometry		3 (3,0)
2	4	ID-250	Linear Algebra		3 (3,0)
3	6	ID-352	Web Technologies	Programming Fundamentals	2 (2,0)
4	6	ID-352-L	Web Technologies Lab	Programming Fundamentals	1 (0,1)
5	6	ID-353	Mobile Application Development	Object Oriented Programming	2 (2,0)
6	6	ID-353-L	Mobile Application Development Lab	Object Oriented Programming	1 (0,1)
7	X	ID-XXX	Introduction to Economics		3 (3,0)
8	X	ID- XXX	Introduction to Psychology		3 (3,0)
9	X	ID- XXX	Introduction to Marketing		3 (3,0)
10	X	ID- XXX	Introduction to Sociology		3 (3,0)
11	X	ID- XXX	Financial Accounting		3 (3,0)
12	X	ID- XXX	Organizational Behavior		3 (3,0)

13	X	ID-XXX	Digital Marketing & E-Commerce		3 (3,0)
14	X	ID-XXX	Media and Information Literacy		3 (3,0)
15	X	ID-XXX	E-Governance and ICT Policy		3 (3,0)
16	X	ID-XXX	Environmental Science		3 (3,0)
17	X	ID-XXX	Technology Management		3 (3,0)
18	X	ID-XXX	Financial Technology (FinTech) Fundamentals		3 (3,0)
19	X	ID-XXX	Geographic Information Systems (GIS)		3 (3,0)
20	X	ID-XXX	Spatial Data		3 (3,0)

Professional Training and Certification: 6 (3,3)					
Sr.	Sem.	Code	Course Title	Prerequisite	Cr. Hrs (Th, Lab)
1	7	PT-380	Professional Certification		3 (3,0)
2	8	PT-381	Field Experience/Internship		3 (0,3)

MATH DEFICIENCY: 6 (6,0)*					
Sr.	Sem.	Code	Course Title	Prerequisite	Cr. Hrs (Th, Lab)
1	1	MD-101	Math Deficiency – I		3 (3,0)*
2	2	MD-102	Math Deficiency – II		3 (3,0)*

** Non-Credit courses with only Pass/Fail grade assigned to the students.*

12. Scheme of Studies and Semester-wise Workload

Semester – I						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	GE-160	Applications of Information & Communication Technologies		GE	2	(2,0)
2	GE-160-L	Applications of Information & Communication Technologies Lab		GE	1	(0,1)
3	GE-169	Applied Physics		GE	3	(2,1)
4	CC-110	Digital Logic Design		CC	3	(3,0)
5	CC-110-L	Digital Logic Design Lab		CC	1	(0,1)
6	GE-196	Islamic Studies		GE	2	(2,0)
7	GE-194	Pakistan Studies		GE	2	(2,0)
8	GE-190	Functional English		GE	3	(3,0)
9	GE-197	Fehm-e-Quran-I		GE	1	(0,1)
10	MD-101	Math Deficiency – I		MD	3*	(3,0)*
Credit Hours (Semester - I)					18	(14,4)

Semester – II						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-112	Programming Fundamentals		CC	3	(3,0)
2	CC-112-L	Programming Fundamentals Lab		CC	1	(0,1)
3	CC-113	Computer Networks		CC	2	(2,0)
4	CC-113-L	Computer Networks Lab		CC	1	(0,1)
5	GE-167	Discrete Structures		GE	3	(3,0)
6	GE-191	Expository Writing		GE	3	(3,0)
7	GE-198	Fehm-e-Quran-II		GE	1	(0,1)
8	GE-170	Introduction to Management		GE	2	(2,0)
9	MD-102	Math Deficiency – II		MD	3*	(3,0)*
Credit Hours (Semester - II)					16	(15,2)

Semester – III						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-211	Object Oriented Programming	Programming Fundamentals	CC	3	(3,0)
2	CC-211-L	Object Oriented Programming Lab	Programming Fundamentals	CC	1	(0,1)
3	CC-111	Computer Organization & Architecture	Digital Logic Design	CC	2	(2,0)
4	CC-111-L	Computer Organization & Architecture Lab	Digital Logic Design	CC	1	(0,1)
5	CC-215	Database Systems		CC	3	(3,0)
6	CC-215-L	Database Systems Lab		CC	1	(0,1)
7	GE-260	Probability and Statistics		GE	3	(3,0)
8	ID-150	Calculus & Analytical Geometry		ID	3	(3,0)
Credit Hours (Semester - III)					17	(14,3)

Semester - IV						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-213	Data Structures	Object Oriented Programming	CC	3	(3,0)
2	CC-213-L	Data Structures Lab	Object Oriented Programming	CC	1	(0,1)
3	CC-216	Operating Systems		CC	3	(3,0)
4	CC-216-L	Operating Systems Lab		CC	1	(0,1)
5	CC-218	Artificial Intelligence		CC	2	(2,0)
6	CC-218-L	Artificial Intelligence Lab		CC	1	(0,1)
7	CC-212	Software Engineering		CC	3	(3,0)
8	ID-250	Linear Algebra		ID	3	(3,0)
Credit Hours (Semester - IV)					17	(14,3)

Semester - V						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-313	Design and Analysis of Algorithms	Data Structures	CC	3	(3,0)
2	EA-320	Programming for AI	Artificial Intelligence	EA	2	(2,0)
3	EA-320-L	Programming for AI Lab	Artificial Intelligence	EA	1	(0,1)
4	CC-219	Theory of Automata		CC	3	(3,0)
5	EA-321	Machine Learning	Artificial Intelligence	EA	2	(2,0)
6	EA-321-L	Machine Learning Lab	Artificial Intelligence	EA	1	(0,1)
7	ID-352	Web Technologies	Programming Fundamentals	ID	2	(2,0)
8	ID-352-L	Web Technologies Lab	Programming Fundamentals	ID	1	(0,1)
9	CC-217	Information Security		CC	3	(3,0)
Credit Hours (Semester - V)					18	(15,3)

Semester - VI						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	EA-322	Deep Learning	Programming for AI	EA	2	(2,0)
2	EA-322-L	Deep Learning Lab	Programming for AI	EA	1	(0,1)
3	EA-324	Game Design and Development	Object Oriented Programming	EA	2	(2,0)
4	EA-324-L	Game Design and Development Lab	Object Oriented Programming	EA	1	(0,1)
5	ID-353	Mobile Application Development	Object Oriented Programming	ID	2	(2,0)
6	ID-353-L	Mobile Application Development Lab	Object Oriented Programming	ID	1	(0,1)
7	CC-314	Cloud Computing	Computer Networks	CC	3	(3,0)
8	EA-323	Knowledge Representation & Reasoning		EA	2	(2,0)
9	EA-323-L	Knowledge Representation & Reasoning Lab		EA	1	(0,1)
Credit Hours (Semester - VI)					15	(11,4)

Semester – VII						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-411	Final Year Project – I		CC	3	(0,3)
2	EA-325	Computer Vision	Deep Learning	EA	2	(2,0)
3	EA-325-L	Computer Vision Lab	Deep Learning	EA	1	(0,1)
4	EA-326	Natural Language Processing	Deep Learning	EA	2	(2,0)
5	EA-326-L	Natural Language Processing Lab	Deep Learning	EA	1	(0,1)
6	PT-380	Professional Certification		PT	3	(3,0)
7	GE-271	Entrepreneurship		GE	2	(2,0)
8	GE-270	Professional Practices		GE	2	(2,0)
Credit Hours (Semester - VII)					16	(11,5)

Semester – VIII						
Sr.	Code	Course Title	Pre-Requisite	Domain	Cr. Hrs.	(Theory, Lab)
1	CC-412	Final Year Project – II	Final Year Project – I	CC	3	(0,3)
2	EA-421	Agentic Artificial Intelligence		EA	2	(2,0)
3	EA-421-L	Agentic Artificial Intelligence Lab		EA	1	(0,1)
4	GE-272	Civics and Community Management		GE	2	(2,0)
5	GE-195	Ideology and Constitution of Pakistan		GE	2	(2,0)
6	PT-381	Field Experience Internship		PT	3	(0,3)
Credit Hours (Semester - VIII)					13	(6,7)
Total Credit Hours					130	(98,32)

Research Thesis / Project /Internship

Final Year Project (6 credit hours, VII & VIII semesters)

13. Course Outlines

Course outlines of all major categories are shared from the next page onwards.

1) Computing Core

Course Title	Digital Logic Design		
Course Code	CC-110		
Credit Hours	3 (3,0)		
Category	Computing core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-111 Computer Organization & Architecture		
Course Introduction	The course introduces the concept of digital logic, gates and the digital circuits. Further, it focuses on the design and analysis combinational and sequential circuits. It also serves to familiarize the student with the logic design of basic computer hardware components.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Acquire the basic knowledge of logic gates and digital logic circuits	C1 (Acquire)	1
	CLO2: Understand the working of the fundamental digital circuits used in digital systems and computers.	C2 (Understand)	1,2
	CLO3: Implement simple digital circuits using logic gates. Designing a digital circuit for implementing a given scenario.	C3 (Apply)	3, 4
	CLO4: Analyze the behavior of digital systems using truth tables and Boolean algebra	C4 (Analyze)	3,4
Syllabus	Topics: Introduction to Digital Systems, Number Systems, Introduction to Boolean Algebra, Basic theorems and properties of Boolean Algebra, Boolean Functions, Logic Gates, NAND and NOR Implementation, Representation of Function in Sum of Minterms or Product of Maxterms, Simplification of Boolean function using Karnaugh Map, Don't care Conditions, The Tabulation Method, Introduction to Combinational Logic, Design of Adders, Design of Subtractors, Code Convertors, Analysis Procedure of Combinational Circuits, Binary Parallel Adders, Decimal Adders, Magnitude Comparator, Decoders and its applications, Multiplexers, Demultiplexers, Encoders, ROM, Programmable Logic Array (PLA), Introduction to Sequential Circuits, Basic Flip Flop, Clocked RS Flip Flop, Clocked D Flip Flop, Clocked JK Flip Flop, Clocked T Flip Flop, Analysis of Clocked Sequential Circuits, State Reduction and Assignment, Flip Flop Excitation tables, Design Procedure, Design of Counters, Design with State Equations, Introduction to Registers, Shift Registers, Ripple Counters, Synchronous Counters, Timing Sequences, Memory Unit, Random Access Memory. Introduction Programmable Logic Devices (CPLD, FPGA), Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim.		
Suggested Instructional/ Reading Material	1. M. Morris Mano, Digital Logic and Computer Design, 1 st Edition, Pearson, 1979, ISBN: 0132145103. 2. Thomas L. Floyd, Digital Fundamentals, 10th Edition, Prentice Hall, 2008, ISBN: 0132359235. 3. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e		

Course Title	Digital Logic Design Lab		
Course Code	CC-110-L		
Credit Hours	1 (0,1)		
Category	Computing core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-111 Computer Organization & Architecture		
Course Introduction	The course introduces the concept of digital logic, gates and the digital circuits. Further, it focuses on the design and analysis combinational and sequential circuits. It also serves to familiarize the student with the logic design of basic computer hardware components.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Acquire the basic knowledge of Digital Electronic Trainer	C1 (Acquire)	1
	CLO2: Understand the pin configuration and working of commonly used ICs for digital circuit design	C2 (Understand)	1,2
	CLO3: Demonstrate the working of the standard digital circuits.	C3 (Demonstrate)	3,4
	CLO4: Designing a digital circuit for implementing a given scenario.	C5 (Design)	3,4
Syllabus	Topics: Familiarization with Digital Electronic Trainer, Implementation of logic gates using ICs, Illustration of basic properties and theorems Boolean algebra using circuit design, Implementation of given Boolean functions, Half Adder, Full Adder, Half Subtractor, Full Subtractor, Design of 7-Segment Display, BCD To 7-Segment Display, Decoder, Multiplexer, Demultiplexer, Implementation of Boolean function(s) using Decoder and Multiplexer, Magnitude Comparator, D Latch and Flip-Flop Operation, Latching BCD Data for Displaying On 7-Segment Display, JK Flip-Flop Operation, Random Access Memories		
Suggested Instructional/ Reading Material	1. M. Morris Mano, Digital Logic and Computer Design, 1st Edition, Pearson, 1979, ISBN: 0132145103. 2. Thomas L. Floyd, Digital Fundamentals, 10th Edition, Prentice Hall, 2008, ISBN: 0132359235. 3. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e		

Course Title	Programming Fundamentals		
Course Code	CC-112		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-211: Object Oriented Programming, ID-352: Web Technologies		
Course Introduction	This course provides fundamental concepts of programming to freshmen. The courses is prerequisite to many other courses, therefore, students are strongly advised to cover all contents and try to achieve CLOs to the maximum possible level.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain core programming concepts including variables, control structures, functions, and data types.	C2 (Understand)	1,2
	CLO2: Demonstrate proficiency in writing, debugging, and executing basic programs using programming languages such as C or Python.	C3 (Apply)	2,3,5
	CLO3: Apply best practices in coding to solve computing problems using efficient and readable programs.	C4 (Analyze)	2,5,7
	CLO4: Analyze program outputs and troubleshoot common errors effectively.	C4 (Analyze)	3,4
Syllabus	Introduction to Problem Solving, Algorithms, Programming, and C Language: Problem Solving, a brief review of Von-Neumann Architecture., The C Programming Language, Pseudo-code, Concept of Variable, Data types in Pseudo-code, The C Standard Library and Open Source, Input/Output, Arithmetic expressions, Assignment statement, Operator precedence, Concept of Integer division, Flowchart and its notations, Typical C Program Development Environment, Role of Compiler and Linker, Test Driving C Application. Introduction to C Programming: A Simple C Program: Printing Text, Adding Two Integer, Memory Concepts, Arithmetic in C, Operators. Decision Making: Equality and Relational Operators. Structured Program Development: The if, if...else, while Nested Control Statements. Program Control: for, switch, do...while, break, continue, Logical Operators. Functions: Modularizing Program in C, Math Library Functions, Function Definitions and Prototypes, Function-Call Stack and Stack Frames, Stack rolling and unrolling, Headers, Passing Arguments by Value and by Reference, Random Number Generation, Scope Rules, Recursion, Recursion vs Iteration. Arrays: Defining Arrays, Character Arrays, Static and Automatic Local Arrays, Passing Arrays to Function, Sorting and Searching Arrays, Multidimensional and Variable Length Arrays. Pointers: Pointer Definitions and Initialization, Pointer Operators, Passing Arguments to Function by Reference, Using the const and sizeof Operator, Pointer Expressions and Arithmetic, Pointers and Arrays, Array of Pointers, Function Pointers. Characters and Strings: Strings and Characters, Character Handling Library, String Functions, Library Functions. Formatted Input/Output: Streams, Formatted Output with printf, Formatted Input with scanf. Structures: Defining Structures, Accessing Structure Member, Structures and Functions, typedef, Unions. Bit Manipulation and Enumeration: Bitwise Operators, Bit Fields, Enumeration Constants. File Processing: Files and Streams, Creating, Reading and Writing data to a Sequential and a Random-Access File. Preprocessor: #include, #define, Conditional Compilation, #error and #pragma, # and ## Operators, Predefined Symbolic Constants, Assertions. Other Topics: Variable Length Argument List, Using Command Line Arguments, Compiling Multiple-Source-File Programs, Program Termination with exit and atexit, Suffixes for Integer and Floating-Point Literals, Signal Handling, Dynamic Memory Allocation calloc and realloc, goto. Advance Topics: Self-Referential Structures, Linked Lists. Efficiency of Algorithms, Selection and Insertion Sort.		
Suggested Instructional/ Reading Material	1. Paul Deitel, Harvey Deitel, C How To Program, 9th Edition, Pearson, 2022. 2. Tony Gaddis, Starting out with Programming Logic and Design, 5th Edition, Pearson, 2018. 3. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie 4. Object Oriented Programming in C++ by Robert Lafore 5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Course Title	Programming Fundamentals Lab		
Code	CC-112-L		
Credit Hours	1 (0,1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-211: Object Oriented Programming, ID-352: Web Technologies, EI-338: Enterprise Systems, EI-327: Information Technology Infrastructure		
Course Introduction	This course provides fundamental concepts of programming to freshmen. The course is prerequisite to many other courses; therefore, students are strongly advised to cover all contents and try to achieve CLOs to the maximum possible level.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain core programming concepts including variables, control structures, functions, and data types.	C2 (Understand)	1,2
	CLO2: Demonstrate proficiency in writing, debugging, and executing basic programs using programming languages such as C or Python.	C3 (Apply)	2,3,5
	CLO3: Apply best practices in coding to solve computing problems using efficient and readable programs.	C4 (Analyze)	2,5,7
	CLO4: Analyze program outputs and troubleshoot common errors effectively.	C4 (Analyze)	3,4
Syllabus	Implementation and Practice of the concepts studied in “CC-112 Programming Fundamentals” Introduction to Problem Solving, Algorithms, Programming, and C Language: Problem Solving, a brief review of Von-Neumann Architecture., The C Programming Language, Pseudo-code, Concept of Variable, Data types in Pseudo-code, The C Standard Library and Open Source, Input/Output, Arithmetic expressions, Assignment statement, Operator precedence, Concept of Integer division, Flowchart and its notations, Typical C Program Development Environment, Role of Compiler and Linker, Test Driving C Application. Introduction to C Programming: A Simple C Program: Printing Text, Adding Two Integer, Memory Concepts, Arithmetic in C, Operators. Decision Making: Equality and Relational Operators. Structured Program Development: The if, if...else, while Nested Control Statements. Program Control: for, switch, do...while, break, continue, Logical Operators. Functions: Modularizing Program in C, Math Library Functions, Function Definitions and Prototypes, Function-Call Stack and Stack Frames, Stack rolling and unrolling, Headers, Passing Arguments by Value and by Reference, Random Number Generation, Scope Rules, Recursion, Recursion vs Iteration. Arrays: Defining Arrays, Character Arrays, Static and Automatic Local Arrays, Passing Arrays to Function, Sorting and Searching Arrays, Multidimensional and Variable Length Arrays. Pointers: Pointer Definitions and Initialization, Pointer Operators, Passing Arguments to Function by Reference, Using the const and sizeof Operator, Pointer Expressions and Arithmetic, Pointers and Arrays, Array of Pointers, Function Pointers. Characters and Strings: Strings and Characters, Character Handling Library, String Functions, Library Functions. Formatted Input/Output: Streams, Formatted Output with printf, Formatted Input with scanf. Structures: Defining Structures, Accessing Structure Member, Structures and Functions, typedef, Unions. Bit Manipulation and Enumeration: Bitwise Operators, Bit Fields, Enumeration Constants. File Processing: Files and Streams, Creating, Reading and Writing data to a Sequential and a Random-Access File. Preprocessor: #include, #define, Conditional Compilation, #error and #pragma, # and ## Operators, Predefined Symbolic Constants, Assertions. Other Topics: Variable Length Argument List, Using Command Line Arguments, Compiling Multiple-Source-File Programs, Program Termination with exit and atexit, Suffixes for Integer and Floating-Point Literals, Signal Handling, Dynamic Memory Allocation calloc and realloc, goto. Advance Topics: Self-Referential Structures, Linked Lists. Efficiency of Algorithms, Selection and Insertion Sort.		
Suggested Instructional/ Reading Material	1. Paul Deitel, Harvey Deitel, C How To Program, 9th Edition, Pearson, 2022. 2. Tony Gaddis, Starting out with Programming Logic and Design, 5th Edition, Pearson, 2018. 3. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie 4. Object Oriented Programming in C++ by Robert Lafore 5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Course Title	Computer Networks		
Course Code	CC-113		
Credit Hours	3 (2, 1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-314 Cloud Computing		
Course Introduction	This course provides fundamental concepts related to Computer Networks. After completion of the course, the students will be able to understand Computer Networks basics, Network types, Layered communication models, and Protocols.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Describe the key terminologies and technologies of Computer Networks	C1 (Remember)	1
	CLO2: Explain the services and functions provided by each layer in the Internet protocol stack	C2 (Understand)	1, 2
	CLO3: Identify various internetworking devices and protocols and their functions in a networking	C3 (Apply)	1, 2, 3
	CLO4: Analyze working and performance of key technologies, algorithms, and protocols	C4 (Analyze)	3, 4, 5
	CLO5: Build Computer Network on various Topologies.	C5 (Evaluate)	4, 5, 6
Syllabus	Introduction: 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, Subnetting, CIDR, Routing protocols, Transport layer protocols, Ports and Sockets, Connection establishment, Flow and Congestion control, Application layer protocols, Latest trends in computer networks. Lab Topics: Introduction to Wireshark, HTTP GET/response interaction, DNS role in the Internet infrastructure, TCP segments sent and received in transferring, UDP transport protocol, IP investigate the IP protocol, NAT behavior of the NAT protocol, DHCP examine the DHCP packets captured, ICMP capturing the packets generated by the Ping program, Ethernet and ARP investigate the Ethernet protocol and the ARP protocol, 802.11 Wireless investigate the 802.11 wireless network protocol, SSL investigate the Secure Sockets Layer (SSL) protocol		
Suggested Instructional/ Reading Material	1. Andrew S. Tanenbaum, Nick Feamster, David J. Wetherall, Computer Networks, 6th Edition, Published by Pearson (July 14, 2021) © 2021, ISBN-13: 9780137523214 (2021 update). 2. James Kurose and Keith Ross, Computer Networking: A top-down,layered approach to computer networking, 8th Edition, Pearson, June 10, 2021, ISBN-13 : 978-1292405469. 3. Todd Lammle, CCNA Cisco Certified Network Associate Deluxe Study Guide, 7th Edition, Wiley Publishing, 2011, ISBN: 978-0470901083. 4. William Stallings, Data and Computer Communications, 11th Edition, Pearson, 2018, ISBN-13: 978-0134997193 5. Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, 6th Edition, McGraw Hill, 3 August 2022, ISBN-13: 978-9355320940 6. Radia Perlman, Interconnections: Bridges, Routers, Switches, and Internetworking Protocols, 2nd Edition, Addison-Wesley, 1999, ISBN: 0201634481.		

Course Title	Object Oriented Programming		
Code	CC-211		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	CC-112 Programming Fundamentals		
Co-Requisite	None		
Follow-up	CC-213 Data Structures, CC-218 Artificial Intelligence, ID-353 Mobile Application Development		
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.		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	BT	PLO
	CLO1: Understand the principles of object-oriented programming, including encapsulation, inheritance, and polymorphism.	C2 (Understand)	1,2
	CLO2: Design and implement classes and objects to model real-world entities using the principles of OOP.	C3 (Apply)	2,4
	CLO3: Write reusable and modular code using OOP concepts.	C3 (Apply)	2,4,5
	CLO4: Analyze the advantages of OOP over procedural programming paradigms.	C4 (Analyze)	2,3
	CLO5: Develop small-scale applications utilizing OOP concepts in languages like Java or C++.	C6 (Create)	2,4,5
Syllabus	Introduction to Object-oriented Design, History and Advantages of Object-oriented Design. Introduction to OOP and C++: Brief description of C++ concepts, Introduction to OOP. Introduction to Classes Objects and Member Functions: Encapsulation and Abstraction, Class and Object, Getter/Setter Functions, Access Specifiers, Constructors, Overloaded Constructor, Default Constructor, Destructor. Functions: Inline Functions, Function Overloading. Class Templates array: Function Templates, Class Templates array, Vectors and Multidimensional Array, Reference to private Data Members, Default Member wise Assignment, const Objects, const Member Functions. Composition and Aggregation: Object Composition and Aggregation, Class Separation using header. Friend Classes and Functions: Friend Functions, Friend Classes. static Members: "this" pointer, static Data Members, static Member Functions. Copy Constructor: Default Copy Constructor. Operator Overloading: Overloaded Operators of Standard Library, Operator Overloading, Overloading Binary Operators, Overloading Unary Operators, Overloading ++ Operator, Overloading – Operator, Dynamic Memory Management, Operators as Members vs Non-Members, Conversion between Types, Explicit Constructor and Conversion Operators, Overloading the Function call Operator. Stream I/O: Introduction, Streams, Streams Input, Streams Output, Object Streams, data and object serialization using object streams. Inheritance: Introduction, Base and Derived Classes, Relationships between Base and Derived Classes, Constructors in Derived Classes, Destructor in Derived Classes, public protected and private Inheritance. Polymorphism: Relationship among Objects in Inheritance, Virtual Functions, Virtual Destructors, Pure Virtual Functions, Abstract and Concrete Classes. File Processing: Files and Streams, create a Sequential File, read a Sequential File, update a Sequential File, Random Access File, create a Random-Access File, read a Random-Access File, update a Random-Access File, Exception Handling: Flow of Control, Rethrowing an Exception, Constructor Destructor and Exception handling. Generic Programming Concepts: Custom Templates, Class Templates, Function Templates, Arguments to Templates, Overloading Function Templates. Standard Library: Containers, Iterators, Adapters, Sequence Containers, Associative Containers, Container Adapters, Minimum Iterator Requirements, Lambda Expressions, Function Objects.		
Suggested Instructional/ Reading Material	1. P. Deitel, H. Deitel, C++ How To Program, 10th Edition, Pearson. 2. Robert Lafore, Object Oriented Programming in C++, 3rd Edition. 3. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, Pearson, 2018. 4. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Title	Object Oriented Programming Lab		
Code	CC-211-L		
Credit Hours	1 (0,1)		
Category	Computing Core		
Prerequisite	CC-112 Programming Fundamentals		
Co-Requisite	None		
Follow-up	CC-213 Data Structures, CC-218 Artificial Intelligence, ID-353 Mobile Application Development		
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.		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	BT	PLO
	CLO1: Understand the principles of object-oriented programming, including encapsulation, inheritance, and polymorphism.	C2 (Understand)	1,2
	CLO2: Design and implement classes and objects to model real-world entities using the principles of OOP.	C3 (Apply)	2,4
	CLO3: Write reusable and modular code using OOP concepts.	C3 (Apply)	2,4,5
	CLO4: Analyze the advantages of OOP over procedural programming paradigms.	C4 (Analyze)	2,3
	CLO5: Develop small-scale applications utilizing OOP concepts in languages like Java or C++.	C6 (Create)	2,4,5
Syllabus	Implementation and Practice of the concepts studied in “CC-211 Object Oriented Programming” Introduction to Object-oriented Design, History and Advantages of Object-oriented Design. Introduction to OOP and C++: Brief description of C++ concepts, Introduction to OOP. Introduction to Classes Objects and Member Functions: Encapsulation and Abstraction, Class and Object, Getter/Setter Functions, Access Specifiers, Constructors, Overloaded Constructor, Default Constructor, Destructor. Functions: Inline Functions, Function Overloading. Class Templates array: Function Templates, Class Templates array, Vectors and Multidimensional Array, Reference to private Data Members, Default Member wise Assignment, const Objects, const Member Functions. Composition and Aggregation: Object Composition and Aggregation, Class Separation using header. Friend Classes and Functions: Friend Functions, Friend Classes. static Members: “this” pointer, static Data Members, static Member Functions. Copy Constructor: Default Copy Constructor. Operator Overloading: Overloaded Operators of Standard Library, Operator Overloading, Overloading Binary Operators, Overloading Unary Operators, Overloading ++ Operator, Overloading – Operator, Dynamic Memory Management, Operators as Members vs Non-Members, Conversion between Types, Explicit Constructor and Conversion Operators, Overloading the Function call Operator. Stream I/O: Introduction, Streams, Streams Input, Streams Output, Object Streams, data and object serialization using object streams. Inheritance: Introduction, Base and Derived Classes, Relationships between Base and Derived Classes, Constructors in Derived Classes, Destructor in Derived Classes, public protected and private Inheritance. Polymorphism: Relationship among Objects in Inheritance, Virtual Functions, Virtual Destructors, Pure Virtual Functions, Abstract and Concrete Classes. File Processing: Files and Streams, create a Sequential File, read a Sequential File, update a Sequential File, Random Access File, create a Random-Access File, read a Random-Access File, update a Random-Access File, Exception Handling: Flow of Control, Rethrowing an Exception, Constructor Destructor and Exception handling. Generic Programming Concepts: Custom Templates, Class Templates, Function Templates, Arguments to Templates, Overloading Function Templates. Standard Library: Containers, Iterators, Adapters, Sequence Containers, Associative Containers, Container Adapters, Minimum Iterator Requirements, Lambda Expressions, Function Objects.		
Suggested Instructional/ Reading Material	1. P. Deitel, H. Deitel, C++ How To Program, 10th Edition, Pearson. 2. Robert Lafore, Object Oriented Programming in C++, 3rd Edition. 3. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, Pearson, 2018. 4. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Course Title	Computer Organization and Architecture		
Course Code	CC-111		
Credit Hours	3 (2,1)		
Category	Computing core		
Prerequisite	CC-110 Digital Logic Design		
Co-Requisite	None		
Follow-up	None		
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.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Describe the structure and function of computer components such as CPU, memory, and I/O devices. and assembly language	C1 (Acquire)	1
	CLO2: Understand the concepts of basic computer organization, architecture, and explain the concepts of instruction set architecture and microarchitecture.	C2 (Understand)	2
	CLO3: Write and understand basic assembly language programs. Optimize programs considering hardware limitations.	C3 (Apply)	3,4,5
	CLO4: Analyze how hardware components interact during program execution.	C4 (Analyze)	3
Syllabus	Topics: Introduction to computer systems, Information is bits + context, Evolution of Intel Microprocessor, Introduction to Assembly Language, Computer Organization, Storage devices hierarchy, The Components of a Microcomputer System, Instruction Cycle, Memory Architecture, Memory Representation & Hierarchy, Data, Address, Control Busses, 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, Intel 8086 family of Microprocessors, Organization of Intel 8088/8086 Processor, 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, Registers and their categories Function of Registers, Memory Addressing, Real Mode Memory Structure, Memory Segmentation (Segment/Offset Scheme), Computer Instructions for Basic computer (Memory Reference, Register Reference and I/O instructions), Addressing modes, Instruction Cycle, Timing and Decoding, RTL of the instructions, Complete flow chart for the Basic Computer Operation, Addressing Modes, Design of the CPU of a basic computer Lab Topics: Assembly Language Syntax, using the gdb debugger, Program data, Variables, Variables, Program Structure, Machine-level representation of programs: a historical perspective, program encodings, data formats, accessing information, arithmetic and logical operations, control, Memory Models, Data Segments, Stack Segment, Code Segment, Variants of MOV instruction, Some Basic Instructions, XCHG, ADD, SUB, INC, DEC, NEG, Input and Output Instructions, The Processor Status and Flags Register, Flow Control Instructions, Unconditional Jump, Various Conditional Jumps, Looping Structures, Logic Instructions, AND, OR, XOR, NOT, TEST, Shift Instructions, Rotate Instructions, Procedures to Input Binary, Decimal, Hexadecimal Numbers, Procedures to output Binary, Decimal, Hexadecimal Numbers, The Stack, PUSH and POP Instructions, CALL and RET instructions, MUL instruction, DIV instruction, Related Programming examples, XLAT instruction, String Instructions, MOVSB/W, LOADSB/W, STOSB/W, SCASB/W, CMPSB/W, Procedures, File Operations, Reading a File, Writing a File		
Suggested Instructional/ Reading Material	1. Charles Marut, Ytha Yu, Assembly Language Programming and Organization of the IBM PC, 1st Edition, McGraw-Hill, 1992, ISBN: 9780070726925. 2. M. Morris Mano, Computer System Architecture, 3rd Edition, Pearson, 1993, ISBN: 9780131755635. 3. Barry B. Brey, The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium Pro-Processor, Pentium II, Pentium III, Pentium 4", 7th Edition, Prentice Hall, 2005, ISBN: 0131195069. 4. Kip R. Irvine, Assembly Language for Intel Based Computers, 4th Edition, Prentice Hall, 2002, ISBN: 9780130910134.		

Course Title	Database Systems		
Course Code	CC-215		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	DI-324: Database Administration and Management		
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		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: To understand the basic concepts of database systems, Database System environment, transaction management, concurrency control, and database recovery.	C2 (Understand)	1
	CLO2: To learn SQL and the fundamentals of PL/SQL. Implement basic database management tasks using popular database management systems.	C3 (Apply)	2,3,4,5
	CLO3: Analysis and Design of conceptual, logical and physical database schemas using different data models. Analyze the role of databases in information systems and their security considerations.	C4 (Analysis)	2,3,4,5
	CLO4: Design and normalize relational database schemas based on user requirements.	C5 (Design)	3,4,5,7
Syllabus	File Systems and Databases: Introduction, A File system Critique, Database Systems, Database approach vs file-based system, database architecture, three level schema architecture, data independence, Database Models. Introduction to RDBMS: Logical view of Data; Entities and Attributes, Tables and their Characteristics, Keys; relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints. Relational Algebra: Relational Database Operators, selection, projection, Cartesian product, types of joins. Entity Relationship (E-R) Modeling: Basic Modeling Concepts, entity sets, attributes, relationship, entity-relationship diagrams, Normalization of Database Tables: Objectives, Forms, Normalization and Database Design, functional dependencies, normal forms, Denormalization, Structured Query Language (SQL): Introduction, DDL Commands, Joins and subqueries in SQL, Grouping and aggregation in SQL, DML Commands, DCL Commands, Complex Queries and SQL Functions, Procedural SQL; Triggers, Stored procedures. Database Design: The System Development Life Cycle (SDLC), The Database Life Cycle (DBLC), Database Design Strategies, Transaction Management and Concurrency Control: Introduction, Transaction Properties and Types, Concurrency Control Issues, Database Recovery Management. DDBMS: Evolution, Components, Distributed processing and distributed databases, Distributed database transparency features. Distributed database design, Data fragmentation, Data replication, NoSQL systems.		
Suggested Instructional/ Reading Material	1. Carlos Coronel, Steven Morris, Database Systems: Design, Implementation & Management, 13th Edition, Cengage Learning, 2017. ISBN-10: 1337627909. 2. Jeffrey A. Hoffer, Ramesh Venkataraman, Heikki Topi, Modern Database Management, 12th Edition, Pearson, 2015. ISBN-10: 0133544613. 3. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015. ISBN-10: 1292061189. 4. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2016. ISBN-10: 1292097612.		

Course Title	Database Systems Lab		
Course Code	CC-215-L		
Credit Hours	1 (0,1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	DI-324: Database Administration and Management		
Course Introduction	The course aims to introduce the Structured Query Language (SQL). It covers the set of commands related to Data Retrieval, Data Definition Language (DDL), Data Manipulation Language (DML), Data Control Language (DCL). It will follow up by procedural flavor of SQL (PL/SQL).		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	BT	PLO
	CLO1: To learn SQL and develop expertise in writing SQL queries	C3 (Apply)	3,4,5
	CLO2: To develop the fundamental knowledge of PL/SQL, stored procedures, and database triggers	C3 (Apply)	3,4,5
	CLO3: To be able to design and implement database system for small business organizations	C5 (Design)	3,4,5,7
Syllabus	Introduction to SQL environment: Writing Basic SQL Statements; SELECT Statement: Arithmetic Expressions, Operator Precedence, Null Value, Column Alias, Concatenation Operator, FROM Clause: Table list, Table Alias. Restricting and Sorting Data; WHERE Clause: Comparison operators, Logical operators, ORDER BY clause, Display table Structure. Single row functions: character functions, number functions, date functions, type conversion functions. Multi row Functions: Sum, Average, Standard deviation, Variance, Subgrouping of data, Group by Clause, use of Having clause. Join: Cross product, natural join, Equi-join, Non equi-join, left outer-join, right outer-join, self-join. Subquery: use of subquery, subquery syntax, Multiple Column Subqueries, pairwise comparison, Non-pair wise comparison, Null Value in a subquery, Subquery in From Clause. Creating and Altering SQL tables: Create table statement, Defining Constraints, Column Level and Table Level, NOT NULL Constraint, UNIQUE Key Constraint, PRIMARY Key Constraint, FOREIGN Key Constraint, CHECK Constraint, Alter table statement, drop statement, Data Manipulation: Insert, Update, Delete statements. SQL Objects: Views, Sequences, Indexes. User Management: Create user, user privileges, user groups, Grant, Revoke statements. Introduction to Procedural SQL (PL/SQL), Sections of a PL/SQL block, Variable declaration and initialization, SELECT statement in PL/SQL, Arithmetic expressions, Selection, Repetition, Exception Handling, Cursors, Stored Procedures and Functions, Introduction to Database Triggers		
Suggested Instructional/ Reading Material	1. Introduction to Oracle 9i: SQL 2. Michael McLaughlin, Oracle Database 11g PL/SQL Programming, 1st Edition, McGraw-Hill Education, 2008, ISBN: 0071494456. 3. Jason Price, Oracle Database 11g SQL, McGraw Hill. ISBN: 0071498508.		

Course Title	Software Engineering		
Course Code	CC-212		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Apply software development life cycle models to manage projects effectively.	C3 (Apply)	2,4
	CLO2: Develop software requirements specifications and design documents.	C6 (Create)	2,4
	CLO3: Implement and test software applications using best practices.	C5 (Evaluate)	2,4,5
	CLO4: Analyze and manage software project risks and quality.	C5 (Evaluate)	2,3,4
	CLO5: Collaborate effectively in team-based software projects.	C6 (Create)	2,6
Syllabus	Introduction: Nature of Software, Overview of Software Engineering, Professional software development, Software engineering practice, Software process structure, Software Process Models: Waterfall Model, Incremental Model, Prototyping Model, Spiral Model, RAD Model. Agile Software Development: Agile process models, Agile development techniques. Introduction to Project Management, Introduction to Requirements Engineering, Functional and non-functional requirements. Analysis Model: Context models, Interaction models, Structural models, behavioral models, model driven engineering, Data modeling, Functional Modeling, Behavioral Modeling. Software Design: Data Design, Architectural Design, Component Level Design, User Interface Design. Object Oriented Analysis & Design Basics: Introduction to UML, UML Diagrams. Use Case Modeling, Rational Rose overview, Use case modeling in Rational Rose. Domain Model: Identifying business classes, Domain Model Associations, Domain Model Attributes, Implementation of Sequence Diagram and Domain model in Rational Rose. Interaction Diagram: Sequence diagrams, Collaboration Diagrams, Implementation of Sequence and Collaboration diagrams in Rational Rose. Design Class Diagram, Mapping Design to Code. Software Testing Fundamentals. Design patterns, Software testing and quality assurance. Software evolution. Project Management: Project planning, configuration management. Software Process improvement.		
Suggested Instructional/ Reading Material	1. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2015, ISBN-13: 978-0133943030. 2. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson, 2002, ISBN-13: 978-0133056990.		

Title	Data Structures		
Code	CC-213		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	CC-211 Object Oriented Programming		
Co-Requisite	None		
Follow-up	CC-313 Design and Analysis of Algorithms, CC-216 Operating Systems, CC-218 Artificial Intelligence		
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.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Implement and analyze various data structures such as arrays, linked lists, stacks, queues, trees, and graphs.	C4 (Analyze)	2,3
	CLO2: Demonstrate proficiency in traversing and manipulating data structures.	C3 (Apply)	2,5
	CLO3: Select and evaluate the efficiency of algorithms based on data structure choices.	C5 (Evaluate)	2,3,4
	CLO4: Solve complex problems using suitable data structures and algorithms.	C6 (Create)	2,4
Syllabus	Algorithm Specification: Properties of Algorithm, examples, performance, analysis, measurement, and Big Oh notation. Introduction to ADTs: Array and Polynomial as an ADT, Sparse Matrices, and Representation of Arrays. The Stack ADT: Linked list and array implementations, Expressions, Postfix Notation, and Infix to postfix conversion. The Queue ADT: Linked and array implementations of circular and double ended queue. Recursion: Recursive Definition and Processes, Writing Recursive Programs. Divide and Conquer Algorithms, Self-Referencing Classes and Dynamic Memory Allocation, Garbage Collection. Linked List: Singly Linked Lists, Circular Lists, Linked Stacks and Queues (Double Ended List), Doubly Linked Lists. Trees: Introduction to Trees, Logical construction and Traversing of Binary Trees, Implementation of Binary Trees (Insertion and Traversing), Searching and deletion in Binary Trees, Binary Search Tree, Introduction to Balanced and AVL Trees. Heaps: Heaps and Heaps as Priority Queues, Double Ended Priority Queue. Searching: Linear Search, Binary Search, and Types of Indexing. Hashing: Hash Functions: Division, Open Addressing; Overflow Handling: Chaining; Introduction to advanced topics: B-Trees, M-Way Trees, Generalized List etc. Sorting: Selection, Insertion, Merge, Quick, Bubble, Heap, Shell, Radix, and Bucket sorts. Graphs: Graph terminology, Adjacency List and Adjacency Matrix and Adjacency list representation of Graph; Elementary Graph Operations: Breadth First Search and Depth First Search, Spanning Trees (BFSST, DFSST), topological order, shortest path.		
Suggested Instructional/ Reading Material	1. Ellis Horowitz, Sartaj Sahni, and D. Mehta, "Fundamentals of Data Structures in C++", 2nd Ed., Computer Science Press 2. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Ed., Cengage Learning 3. Mark Allen Weiss, "Data Structure and Algorithms in C++", 2nd Ed., Pearson Education 4. D. Malhotra and N. Malhotra. Data Structures and Program Design Using C++. 5. Tenenbaum, M. Augenstein, and Y. Lang Sam, "Data Structures using C and C++" 2nd Ed., Prentice Hall		

Course Title	Data Structures Lab		
Code	CC-213-L		
Credit Hours	1 (0,1)		
Category	Computing Core		
Prerequisite	CC-211 Object Oriented Programming		
Co-Requisite	None		
Follow-up	CC-313 Analysis of Algorithms, EI-325 Cyber Security, CC-216 Operating Systems		
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.		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	BT	PLO
	CLO1: Implement and analyze various data structures such as arrays, linked lists, stacks, queues, trees, and graphs.	C4 (Analyze)	2,3
	CLO2: Demonstrate proficiency in traversing and manipulating data structures.	C3 (Apply)	2,5
	CLO3: Select and evaluate the efficiency of algorithms based on data structure choices.	C5 (Evaluate)	2,3,4
	CLO4: Solve complex problems using suitable data structures and algorithms.	C6 (Create)	2,4
Syllabus	Implementation and Practice of the concepts studied in “CC-213 Data Structures” Algorithm Specification: Properties of Algorithm, examples, performance, analysis, measurement, and Big Oh notation. Introduction to ADTs: Array and Polynomial as an ADT, Sparse Matrices, and Representation of Arrays. The Stack ADT: Linked list and array implementations, Expressions, Postfix Notation, and Infix to postfix conversion. The Queue ADT: Linked and array implementations of circular and double ended queue. Recursion: Recursive Definition and Processes, Writing Recursive Programs. Divide and Conquer Algorithms, Self-Referencing Classes and Dynamic Memory Allocation, Garbage Collection. Linked List: Singly Linked Lists, Circular Lists, Linked Stacks and Queues (Double Ended List), Doubly Linked Lists. Trees: Introduction to Trees, Logical construction and Traversing of Binary Trees, Implementation of Binary Trees (Insertion and Traversing), Searching and deletion in Binary Trees, Binary Search Tree, Introduction to Balanced and AVL Trees. Heaps: Heaps and Heaps as Priority Queues, Double Ended Priority Queue. Searching: Linear Search, Binary Search, and Types of Indexing. Hashing: Hash Functions: Division, Open Addressing; Overflow Handling: Chaining; Introduction to advanced topics: B-Trees, M-Way Trees, Generalized List etc. Sorting: Selection, Insertion, Merge, Quick, Bubble, Heap, Shell, Radix, and Bucket sorts. Graphs: Graph terminology, Adjacency List and Adjacency Matrix and Adjacency list representation of Graph; Elementary Graph Operations: Breadth First Search and Depth First Search, Spanning Trees (BFSST, DFSST), topological order, shortest path.		
Suggested Instructional/ Reading Material	1. Ellis Horowitz, Sartaj Sahni, and D. Mehta, “Fundamentals of Data Structures in C++”, 2nd Ed., Computer Science Press 2. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Ed., Cengage Learning 3. Mark Allen Weiss, “Data Structure and Algorithms in C++”, 2nd Ed., Pearson Education 4. D. Malhotra and N. Malhotra. Data Structures and Program Design Using C++. 5. Tenenbaum, M. Augenstein, and Y. Lang Sam, “Data Structures using C and C++” 2nd Ed., Prentice Hall		

Course Title	Operating Systems		
Course Code	CC-216		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up			
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.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the characteristics of different structures of the Operating Systems. Explain the functions and services provided by operating systems.	C2 (Understand)	1,2
	CLO2: Demonstrate the knowledge in applying system software and tools available in modern operating systems. Implement basic scheduling algorithms.	C3 (Demonstrate, Apply)	3,4
	CLO3: 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	C4 (Analyze)	3
	CLO4: Evaluate operating system performance and security features.	C6 (Evaluate)	2,4,5
Syllabus	Introduction: 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. Interacting with Linux Operating System: Virtualization and Hypervisors. Installation of VMWare and Ubuntu, Installation G++ the C++ Compiler on Ubuntu VMWare, Basic commands of Linux, Working with VIM editor, Compiling and executing a C/C++ program in VIM, File System Architecture: Schematic view of a standard UNIX file system. File System Mounting: Introduction to the concept of file system mounting. Linux configuration files related to file system mounting. File Permissions: standard file permissions. Use of chmod and chown commands. Device files: Seven File Types in Linux and the concept of device files. Terminal Attributes: Overview of Terminal Devices and current attributes of the terminal driver. Hard and Soft Links. Managing services using systemd: Introduction to Linux system daemon. Shell commands to manage services using systemctl. Booting process of a Linux system. Linux Shell Programming: Linux System Call Interface, Use of GNU gcc compiler, Implementation of process scheduling algorithms, Process Creation and Termination: getpid(), getppid(), fork(), exit(), wait() and execl() system calls. File management in Linux. Concept of PPFDT. Concept of input, output and error redirection. Inter Process Communication: Linux IPC tools, Pipes, FIFOs and Sockets. Use of pipes and fifos on a Linux terminal. Signals: Signal delivery and execution of a signal handler. Synchronous and Asynchronous signals. Threads and Scheduling: Writing multi-threaded C programs using library calls from the POSIX pthread library like pthread_create(), pthread_join(), and pthread_exit(), Socket programming using threads in Linux, Implementation of process synchronization techniques		
Suggested Instructional/ Reading Material	1. A. Silberschatz, P. B. Galvin, G. Gagne, Operating Systems Concepts, 9th Edition, Wiley, 2012, ISBN: 1118063333. 2. Andrew S. Tanenbaum, Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2014, ISBN: 013359162X. 3. William Stallings, Operating Systems: Internals and Design Principles, 9th Edition, Pearson, 2017, ISBN: 0134670957.		

Course Title	Operating Systems Lab		
Course Code	CC-216-L		
Credit Hours	1 (0,3)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up			
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.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the fundamentals of Linux operating system, Linux commands, virtual machines,	C2 (Understand)	1,2
	CLO2: Installation of VMWare and Ubuntu. Compiling and executing a C/C++ program in VIM editor. Demonstrate the knowledge in applying system software and tools available in modern operating systems. Linux shell programming.	C3 (Apply, Demonstrate)	3,4,5
Syllabus	Interacting with Linux Operating System: Virtualization and Hypervisors. Installation of VMWare and Ubuntu, Installation G++ the C++ Compiler on Ubuntu VMWare, Basic commands of Linux, Working with VIM editor, Compiling and executing a C/C++ program in VIM, File System Architecture: Schematic view of a standard UNIX file system. File System Mounting: Introduction to the concept of file system mounting. Linux configuration files related to file system mounting. File Permissions: standard file permissions. Use of chmod and chown commands. Device files: Seven File Types in Linux and the concept of device files. Terminal Attributes: Overview of Terminal Devices and current attributes of the terminal driver. Hard and Soft Links. Managing services using systemd: Introduction to Linux system daemon. Shell commands to manage services using systemctl. Booting process of a Linux system. Linux Shell Programming: Linux System Call Interface, Use of GNU gcc compiler, Implementation of process scheduling algorithms, Process Creation and Termination: getpid(), getppid(), fork(), exit(), wait() and execl() system calls. File management in Linux. Concept of PPFDT. Concept of input, output and error redirection. Inter Process Communication: Linux IPC tools, Pipes, FIFOs and Sockets. Use of pipes and fifos on a Linux terminal. Signals: Signal delivery and execution of a signal handler. Synchronous and Asynchronous signals. Threads and Scheduling: Writing multi-threaded C programs using library calls from the POSIX pthread library like pthread_create(), pthread_join(), and pthread_exit(), Socket programming using threads in Linux, Implementation of process synchronization techniques		
Suggested Instructional/ Reading Material	Unix: The Text Book, 3rd edition by Sarwar and Koretsky, ISBN-13: 978-1-4822-3358-2		

Course Title	Information Security		
Course Code	CC-217		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This core-computing 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.		
Course Objectives	• Introduction to Information Security of different types of Information Systems. • To be able to identify Computer System threats. • To be able to identify Malware attacks, and understand the stages of attack and payloads. • To be able to understand basic Cryptographic techniques. • Introduction to the Information Security Laws of Pakistan, US, UK, and EU.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	: Explain key concepts of information security such as Design principles, Cryptography, Risk management, and Ethics.	C1 (Remember)	1, 2
	: Discuss Legal, Ethical, and Professional issues in Information Security.	C2 (Understand)	1, 2
	: Apply various security and risk management tools for achieving Information Security and Privacy.	C3 (Apply)	3, 4, 5
	: Identify appropriate techniques to tackle and solve problems in the discipline of information security.	C4 (Analyze)	3, 4, 5, 6
Syllabus	Information Security foundations, Security design principles; Security mechanisms, Symmetric and Asymmetric Cryptography, Encryption, Hash functions, Digital signatures, Key management, Authentication and Access control, OWASP Top 10 Web Application Security Risks, Software security, Vulnerabilities and Protections, Common Vulnerabilities and Exposures (CVE), Vulnerability Metrics, National Vulnerability Database (NVD), Common Vulnerability Scoring System (CVSS), 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 i.e. Tor Project (https://www.torproject.org/), Tor Browser.		
Suggested Instructional/ Reading Material	1. Michael E. Whitman and Herbert J. Mattord, Principles of Information Security, 6th edition, CENGAGE Learning. 2. William Stallings, Lawrie Brown, Computer Security: Principles and Practice, 5th Edition, Published by Pearson, 2024. 3. William Chuck Easttom, Computer Security Fundamentals, 5th Edition, Pearson Education. 4. Dieter Gollmann, Computer Security, Third Edition, Hamburg University of Technology, WILEY 5. Ross Anderson, Security Engineering, Third Edition, A Guide to Building Dependable Distributed Systems, WILEY, 2020 6. Dafydd Stuttard, Marcus Pinto, The Web Application Hacker's Handbook, Finding and Exploiting Security Flaws, Second Edition, WILEY 7. Mark Ciampa, CompTIA Security+ Guide to Network Security Fundamentals, 7th Edition, Information Security, CENGAGE. 8. Randall J. Boyle, Raymond R. Panko, Corporate Computer Security, 4th Edition, PEARSON. 9. Charles Pfleeger, Shari Lawrence Pfleeger, Lizzie Coles-Kemp, Security in Computing, 6th Edition, The Art of Computer and Information Security: From Apps and Networks to Cloud and Crypto Security in Computing, Addison-Wesley.		

Course Title	Design and Analysis of Algorithms		
Code	CC-313		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	CC-213: Data Structures		
Co-Requisite	None		
Follow-up	None		
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.		
Course Learning Outcomes (CLOs)	On completion of this course, the students will be able to:	BT	PLO
	CLO1: Explain the fundamental concepts of algorithm analysis, including time and space complexity, asymptotic notation, and recurrence relations.	C2 (Understand)	1,2
	CLO2: Apply algorithm design techniques such as divide-and-conquer, greedy methods, and dynamic programming to solve computational problems.	C3 (Apply)	2,3,4
	CLO3: Analyze the efficiency and correctness of algorithms using formal methods such as worst-case, average-case analysis, and loop invariants using Big-O notation.	C4 (Analyze)	2,3,4
	CLO4: Design efficient algorithms to solve problems related to sorting, searching, graphs, and optimization, with attention to performance trade-offs.	C6 (Create)	3,4,5
	CLO5: Evaluate and compare alternative algorithmic approaches to determine the most appropriate solution based on complexity, correctness and constraints.	C5 (Evaluate)	3,4
Course Contents / Syllabus	Topics: Role of Algorithm in Computing, Analysis on nature of input and size of input , Designing Algorithms, Growth of Functions, Asymptotic Notations, Big-O, Big Ω , Big Θ , little-o, little- ω , loop invariants, Brute Force Approach, Divide-and-conquer approach; Sorting Algorithm analysis, Merge, Quick Sort, Greedy approach; Recursion and recurrence relations, Time Complexity of Recursive Algorithms, Algorithm Design Techniques, Dynamic Programming, Greedy Algorithms, String Matching, Search trees; Heaps; Hashing; Graph algorithms, sparse graphs, DFS, BFS, Minimum Spanning Trees, Shortest Path Algorithms, NP Completeness, Polynomial Time Algorithm, Polynomial Time verification.		
Textbook	1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, 3 rd Edition, The MIT Press, 2009, ISBN-10: 0262033844, ISBN-13: 978-0262033848		
Suggested Instructional/ Reading Material	1. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos 2. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne		

Course Title	Theory of Automata		
Course Code	CC-219		
Credit Hours	3 (3,0)		
Category	Domain Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course aims to provide students with a comprehensive foundation in the theory of computation, focusing on formal models such as finite automata, regular expressions, context-free grammars, and Turing machines. Emphasis is placed on developing analytical thinking and problem-solving skills through the design and analysis of computational systems. By the end of the course, students will have the theoretical understanding and practical insight needed to analyze the limits of computation and pursue advanced studies in computer science.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain finite automata, regular expressions & formal languages	C2 (Understand)	1,2
	CLO2: Demonstrate equivalence of automata, regular expressions & grammars. Apply automata theory to compiler design & language processing	C3 (Apply)	2,3,4,5
	CLO3: Analyze limitations of finite automata & context-free grammars	C4 (Analyze)	2,3,4
	CLO4: Design automata to recognize specific languages	C6 (Create)	2,4
Syllabus	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.		
Suggested Instructional/ Reading Material	1. Daniel I. A. Cohen, "Introduction to computer theory", 2nd Ed., Wiley India Pvt. Limited, 2007. ISBN 0471137723, 9780471137726 2. Peter Linz, "An Introduction to Formal Languages and Automata", 5th Ed., Jones & Bartlett Publishers, 2011. ISBN: 144961552X, 9781449615529 3. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich, 2011 4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Xavier, 2005, New Age Publishers		

Course Title	Cloud Computing		
Course Code	CC-314		
Credit Hours	3 (2,1)		
Category	Computing Core		
Prerequisite	CC-113: Computer Networks		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Nowadays cloud computing becomes popular for individuals' users as well as for the business community. It provides on-demand huge computation and storage resources which is attractive for a large number of users mainly due to pay-per-usage charging model. This course will introduce topics related to Cloud Computing and also expose students to the latest tools and technologies used in Cloud Computing. The aim of this course is to provide an in-depth knowledge of Cloud Computing topics. The course would also expose students to important methods and tools used Cloud Computing.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain Cloud computing, virtualization, Docker and scalable web applications.	C2 (Explain)	1,2
	CLO2: Familiarize with Load Balancing AWS ELB, Nginx, Ipvadm, Ldirectord.	C1 (Know)	1,2
	CLO3: Demonstrate the use of NoSQL, MongoDB and DynamoDB, Revision, MapReduce	C3 (Apply)	3,4,5
	CLO4: Explain Big Data transformation methods.	C2 (Explain)	2,4,5
Syllabus	Introduction To Cloud Computing, Introduction To Cloud Computing (Cont.), AWS Services, EC2 hands, Accessing AWS S3 , Virtualization , Containerization/Dockers, Scalable Web Application in The Cloud, Scalable Web Application in The Cloud (Cont.), Load Balancing AWS ELB, Nginx, Ipvadm, Ldirectord, Web Application Deployment Models, Introduction to Big Data, Introduction to Big Data (Cont.), Introduction to NoSQL, MongoDB and DynamoDB, Revision, MapReduce, Distributed Systems, Consistency and Fault Tolerance in Distributed Systems, Big Data Transformation Methods , Blockchain, Practical Considerations in Cloud Computing, Future of the Cloud Computing and Big Data		
Suggested Instructional/ Reading Material	1. JothyRosenberg and Arthur Mateos;The Cloud at Your Service;Manning Publications. ISBN: 1935182528 2. Paul Zikopoulos and Chris Eaton; Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data; McGraw-Hill. ISBN: 0071790535 3. Kyle Banker, Peter Bakkum, Shaun Verch, Douglas Garrett, and Tim Hawkins; MongoDB in Action, Second Edition. 4. Clinton W. Brownley; Foundations for Analytics with Python from Non-Programmer to Hacker.		

Course Title	Artificial Intelligence			
Course Code	CC-218			
Credit Hours	3 (2,1)			
Category	Computing core			
Prerequisite	None			
Co-Requisite	CC-213: Data Structures			
Follow-up	None			
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.			
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:		BT	PLO
	CLO1: Describe core AI concepts including search algorithms, knowledge representation, and reasoning.		C2 (Understand)	1,2
	CLO2: Implement basic AI algorithms for problem-solving and decision-making.		C3 (Apply)	3,4,5
	CLO3: Analyze the applications of AI in real-world scenarios.		C4 (Analyze)	1,2,3
	CLO4: Discuss ethical considerations and limitations of AI systems.		C5 (Evaluate)	8,9
	CLO5: Develop simple AI models using appropriate tools and frameworks.		C6 (Create)	2,4,5
Syllabus	An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Symbolic AI: the physical symbol system hypothesis. Search: exhaustive & heuristic search techniques. 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, Game playing, Genetic algorithms, Introduction to Machine Learning for AI, Decision Trees, Bayesian classification, Artificial Neural Networks, Computer Vision. Lab Topics: Introduction to Python programming, variables, expressions, operands and operators, loops, control structures, debugging, error messages, functions, strings, lists, object-oriented constructs and basic graphics in the languages. Logic programming: knowledge representation & search in the context of logic programming. Reasoning in logic programming: unification, horn clause logic, and resolution, Knowledge Representation Schemas: Logic, frames, semantic nets, scripts; problems in knowledge representation. Expert systems.			
Suggested Instructional/ Reading Material	1. Stuart Russell and Peter Norvig, Artificial Intelligence. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2015. 2. Luger, G.F. and Stubblefield, W.A., 2009. AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley. 3. George F. Luger, Artificial Intelligence - Structures and Strategies for Complex Problem Solving, 6th Edition, Pearson, 2008, ISBN-13: 978-0321545893. 4. Hart, P.E., Stork, D.G. and Duda, R.O., Pattern classification. John Wiley & Sons, 2001. 5. P. Winston, Artificial Intelligence, 3rd Edition, Pearson, 1992, ISBN-13: 978-0201533774. 6. Tony Gaddis, "Starting out with Python", 4th Edition, Pearson Education, 2017. 7. Ivan Bratko, Prolog: Programming for Artificial Intelligence, 4th Edition, Pearson, 2011, ISBN-13: 978-0321417466. 8. Severance, C.R., "Python for everybody: Exploring data using Python 3." CreateSpace Independent Publ Platform, 2016. 9. Miller, B.N., Ranum, D.L. and Anderson, J., "Python programming in context." Jones & Bartlett Pub., 2019. 10. McKinney, W., "Python for data analysis: Data wrangling with Pandas, NumPy, and IPython.", 2nd Edition O'Reilly Media, Inc., 2023. 11. Joshi, P., 2017. "Artificial intelligence with python." Packt Publishing Ltd. 12. Handouts and Internet references			

2) General Education

Course Title	Applications of Information & Communication Technologies		
Course Code	GE-160		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Introduction	This course is designed to provide students with an exploration of the practical applications of Information and Communication Technologies (ICT) and software tools in various domains. Students will gain hands-on experience with a range of software applications, learning how to leverage ICT to solve daily life problems, enhance productivity and innovate in different fields. Through individual and interactive exercises and discussions, students will develop proficiency in utilizing software for communication, creativity, and more.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain the fundamental concepts, components, and scope of ICT.	C2 (Explain)	1,2
	CLO2: Identify uses of various ICT platforms and tools for different purposes.	C4 (Identify)	1,2,3
	CLO3: Apply ICT platform and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.	C3 (Apply)	3,4,5
	CLO4: Understand the ethical and legal considerations in use of ICT platforms and tools.	C2 (Understand)	1,2,3
Syllabus	Introduction to ICT Components of ICT (basics of hardware, software, ICT platforms, networks, local and cloud data storage, etc.), Scope of ICT (use of ICT in education, business, governance, healthcare, digital media and entertainment, etc.), Emerging technologies and future trends. Basic ICT Productivity Tools: Effective use of popular search engines to explore WWW, Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.) Microsoft Office Suites (Word, Excel, PowerPoint), Google Workspace (Google Docs, Sheets, Slides), Google Drive, Dropbox (cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft integration), Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas), Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.), social media applications (LinkedIn, Facebook, Instagram, etc.) ICT in Education: Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.), Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.), Interactive multimedia and virtual classrooms ICT in Health and Well-being: Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkeeper, etc.), Telemedicine and online health consultations (OLADOC, Sehat Kahani, Mahram, etc.) ICT in Personal Finance and Shopping: Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, 1Link and MNET, Keenu Wallet, etc.), E-commerce platforms. Digital Citizenship and Online Etiquette: Intellectual property and copyright issues, Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources, Content accuracy and integrity (ensuring that the content share through ICT platforms is free from misinformation, fake news, and manipulation).		
Practical Requirements	1. Guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as word processing software (e.g., Microsoft Word), presentation software, (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools. Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets etc. 2. Assigning of tasks that involve creating, managing, and organizing files and folders on both local and cloud storage systems. Students will practice file naming conventions, creating		

	directories, and using cloud storage solutions (e.g., Google Drive, OneDrive). 3. The use of online learning management systems (LMS) where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with the practical experience with online platforms commonly used in education and the workplace.
Suggested Instructional/ Reading Material	1. "Discovering Computers" by Vermaat, Shaffer, and Freund. 2. Deborah Morley and Charles S. Parker, Understanding Computers: Today and Tomorrow, 16th edition, Cengage Learning, 2016, ISBN-13: 978-1337251853 3. "Computing Essentials" by Morley and Parker. 4. "GO! With Microsoft Office" Series by Gaskin, Vargas, and McLellan. 5. "Exploring Microsoft Office" Series by Grauer and Poatsy. 6. "Technology in Action" by Evans, Martin and Poatsy. 7. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017. 8. Joan Lambert, Curtis Frye, Microsoft Office 2019 Step by Step, First Edition. ISBN: 978-1-50-930597-1.

Course Title	Applications of Information & Communication Technologies Lab		
Course Code	GE-160-L		
Credit Hours	1 (0,1)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain the fundamental concepts, components, and scope of ICT.	C2 (Explain)	1,2
	CLO2: Identify uses of various ICT platforms and tools for different purposes.	C4 (Identify)	1,2,3
	CLO3: Apply ICT platform and tools for different purposes to address basic needs in different domains of daily, academic, and professional life.	C3 (Apply)	3,4,5
	CLO4: Understand the ethical and legal considerations in use of ICT platforms and tools.	C2 (Understand)	1,2,3
Syllabus	Implementation of courses contents applications of Information and Communication Technologies: Interaction with components of ICT (basics of hardware, software, ICT platforms, networks, local and cloud data storage, etc.), Basic ICT Productivity Tools: Effective use of popular search engines to explore WWW, Formal communication tools and etiquettes (Gmail, Microsoft Outlook, etc.) 1. Guided tutorials and exercises to ensure that students are proficient in commonly used software applications such as word processing software (e.g., Microsoft Word), presentation software, (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel) among such other tools, Google Workspace (Google Docs, Sheets, Slides), Dropbox (cloud storage and file sharing), Google Drive (Cloud storage with Google Docs integration) and Microsoft OneDrive (Cloud storage with Microsoft integration), Evernote (Note-taking and organization applications) and OneNote (Microsoft's digital notebook for capturing and organizing ideas), Video conferencing (Google Meet, Microsoft Teams, Zoom, etc.), social media applications (LinkedIn, Facebook, Instagram, etc.). ICT in Education: Working with learning management systems (Moodle, Canvas, Google Classrooms, etc.), Sources of online education courses (Coursera, edX, Udemy, Khan Academy, etc.), Interactive multimedia and virtual classrooms. ICT in Health and Well-being: Health and fitness tracking devices and applications (Google Fit, Samsung Health, Apple Health, Xiaomi Mi Band, Runkeeper, etc.), Telemedicine and online health consultations (OLADOC, Sehat Kahani, Mahram, etc.). ICT in Personal Finance and Shopping: Online banking and financial management tools (JazzCash, Easypaisa, Zong PayMax, 1Link and MNET, Keenu Wallet, etc.), E-commerce platforms. Digital Citizenship and Online Etiquette: Intellectual property and copyright issues, Ensuring originality in content creation by avoiding plagiarism and unauthorized use of information sources, Content accuracy and integrity (ensuring that the content share through ICT platforms is free from misinformation, fake news, and manipulation). Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets etc.		
Suggested Instructional/ Reading Material	1. "Discovering Computers" by Vermaat, Shaffer, and Freund. 2. Deborah Morley and Charles S. Parker, Understanding Computers: Today and Tomorrow, 16th edition, Cengage Learning, 2016, ISBN-13: 978-1337251853 3. "Computing Essentials" by Morley and Parker. 4. "GO! With Microsoft Office" Series by Gaskin, Vargas, and McLellan. 5. "Exploring Microsoft Office" Series by Grauer and Poatsy. 6. "Technology in Action" by Evans, Martin and Poatsy. 7. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017. 8. Joan Lambert, Curtis Frye, Microsoft Office 2019 Step by Step, First Edition. ISBN: 978-1-50-930597-1.		

Course Title	Applied Physics		
Course Code	GE-169		
Credit Hours	3 (2,1)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Introduction	The primary objective of the course is to teach student calculus based general physics, particularly basic concepts of electrostatics, electricity, magnetism and optics. To equip the learner with the basic philosophy of different physical phenomenon. To make them able to solve to given physical problems related to the subject. To lay strong foundations of their basic scientific knowledge.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: To understand the fundamental concepts of Physics.	C2 (Understand)	1,2
	CLO2: To understand about charges and their interactions.	C2 (Understand)	1,2
	CLO3: To develop strong concepts of numerical techniques related to vectors and electrostatics and magnetism.	C2 (Understand)	1,2
	CLO4: To develop the relation between electricity and magnetism.	C4 (Analyze)	1,2,3
Syllabus	Electric force: Introduction to electric force, its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charged isolated conductor. Electric potential energy: Electric potentials, Calculating the potential from the field and related problem Potential due to point and continuous charge distribution, Potential due to dipole, equipotential surfaces, Calculating the field from the potential. Electric current: Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot- Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroids, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf. Induced electric field, Induced electric fields. Electromagnetics: The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.		
Suggested Instructional/ Reading Material	1. D. Halliday, R. Resnick, Kenneth S. Krane, Physics Vol. 2, 5th Ed., John Wiley, 2001, ISBN: 978-0471401940. 2. Hugh D. Young, Roger A. Freedman, A. Lewis, Sears, University Physics, 11th Ed., Benjamin-Cummings Pub. Co., 2004, ISBN: 978-0805391794. 3. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, 6th Ed., Wiley, 2010, ISBN: 978-0470469118.		

Title	Functional English		
Code	GE-190		
Credit Hours	3 (3,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	GE-191 Expository Writing		
Course Introduction	This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and analytical skills in listening and reading. Moreover, the course encompasses a range of practical communication aspects including professional writing, public speaking, and everyday conversation, ensuring that students are equipped for both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact in their functional interactions.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Apply enhanced English communication skills by effectively expressing information, ideas, and opinions in written and spoken forms through appropriate word choices, grammar, and sentence structure.	C3 (Apply)	1,6,7,10
	CLO2: Comprehend a variety of literary / non-literary written and spoken texts in English.	C2 (Understand)	1,6,7,10
	CLO3: Analyze inter-cultural variations in the use of the English language to determine how communication style and content should be adapted for diverse cultural and social contexts.	C4 (Analyze)	1,6,7,10
Course Contents / Syllabus	Foundations of Functional English: Vocabulary building (contextual usage, synonyms, antonyms and idiomatic expressions), Communicative grammar (subject-verb-agreement, verb tenses, fragments, run-ons, modifiers, articles, word classes, etc.), Word formation (affixation, compounding, clipping, back formation, etc.), Sentence structure (simple, compound, complex and compound-complex), Sound production and pronunciation. Comprehension and Analysis: Understanding purpose, audience and context, Contextual interpretation (tones, biases, stereotypes, assumptions, inferences, etc.), Reading strategies (skimming, scanning, SQ4R, critical reading, etc.), Active listening (overcoming listening barriers, focused listening, etc.). Effective Communication: Principles of communication (clarity, coherence, conciseness, courteousness, correctness, etc.), Structuring documents (introduction, body, conclusion and formatting), Inclusivity in communication (gender-neutral language, stereotypes, cross-cultural communication, etc.), Public speaking (overcoming stage fright, voice modulation and body language), Presentation skills (organization content, visual aids and engaging the audience), Informal communication (small talk, networking and conversational skills), Professional writing (business e-mails, memos, reports, formal letters, etc.)		
Suggested Instructional / Reading Material	1. "Understanding and Using English Grammar" by Betty Schramper Azar. 2. "English Grammar in Use" by Raymond Murphy. 3. "The Blue Book of Grammar and Punctuation" by Jane Straus. 4. "English for Specific Purposes: A Learning-Centered Approach" by Tom Hutchinson and Alan Waters. 5. "Cambridge English for Job-hunting" by Colm Downes. 6. "Practical English Usage" by Michael Swan. 7. "Reading Literature and Writing Argument" by Missy James and Alan P. Merickel. 8. "Improving Reading: Strategies, Resources, and Common Core Connections" by Jerry Johns and Susan Lenski. 9. "Comprehension: A Paradigm for Cognition" by Walter Kintsch. 10. "Communication Skills for Business Professionals" by J.P. Verma and Meenakshi Raman.		

Title	Expository Writing
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Code	GE-191		
Credit Hours	3 (3,0)		
Category	General Education		
Prerequisite	GE-190: Functional English		
Co-Requisite	None		
Follow-up			
Course Introduction	Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation of the pre-requisite course, Functional English, this course will enhance students' abilities of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the stages of the writing process—including pre-writing, drafting, editing, and proofreading—and their role in producing clear, well-structured essays.	C2 (Understand)	1,6,7,10
	CLO2: Apply appropriate expository writing techniques and uphold ethical practices to create original texts tailored to specific purposes and audiences.	C3 (Apply)	1,6,7,10
	CLO3: Analyze written texts to evaluate their structure, coherence, and style.	C4 (Analyze)	1,6,7,9
Course Contents / Syllabus	Introduction to Expository Writing: Understanding expository writing (definition, types, purpose and applications), Characteristics of effective expository writing (clarity, coherence and organization), Introduction to paragraph writing. The Writing Process: Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.), Drafting (three stage process of drafting techniques), Revising and editing (ensuring correct grammar, clarity, coherence, conciseness etc.), Proof reading (fine-tuning of the draft), Peer review and feedback (providing and receiving critique). Essay Organization and Structure: Introduction and hook (engaging readers and introducing the topic), Thesis statement (crafting a clear and focused central idea), Body Paragraphs (topic sentences, supporting evidence and transitional devices), Conclusion (types of concluding paragraphs and leaving an impact), Ensuring cohesion and coherence (creating seamless connections between paragraphs). Different Types of Expository Writing: Description, Illustration, Classification, Cause and effect (exploring causal relationships and outcomes), Process analysis (explaining step-by-step procedures), Comparative analysis (analyzing similarities and differences). Writing for Specific Purposes and Audiences: Different types of purposes (to inform, to analyze, to persuade, to entertain etc.), Writing for academic audiences (formality, objectivity, and academic conventions), Writing for public audiences (engaging, informative and persuasive language), Different tones and styles for specific purposes and audiences. Ethical Considerations: Ensuring original writing (finding credible sources, evaluating information etc.), Proper citation and referencing (APA, MLA, or other citation styles), Integrating quotes and evidences (quoting, paraphrasing, and summarizing), Avoiding plagiarism (ethical considerations and best practices)		
Practical Requirements	As part of the overall learning requirements, students will be required to build a writing portfolio having a variety of expository texts and present the same at the end of the course showcasing proficiency in expository writing.		
Suggested Instructional / Reading Material	1. "The St. Martin's Guide to Writing" by Rise B. Axelrod and Charles R. Cooper. 2. "They Say / I Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein. 3. Birkenstein. 4. "Writing Analytically" by David Rosenwasser and Jill Stephen. 5. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup. 6. "The Elements of Style" by William Strunk Jr. and E.B. White. 7. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer. 8. "Writing to Learn; How to Write – and Think – Clearly About Any Subject at All" by William Zinsser. 9. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg. 10. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan. 11. "Writing Today" by Richard Johnson-Sheehan and Charles Paine.		

Course Title	Probability and Statistics		
Course Code	GE-260		
Credit Hours	3 (3,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know the concept and applications of probability and statistics.	C1 (Know)	1
	CLO2: Describe expectation and distributions	C2 (Describe)	1
	CLO3: Solve single sample and one- and two- sample estimation.	C3 (Apply)	1,3
	CLO4: Use regression techniques.	C3 (Apply)	1,3
Syllabus	Introduction: 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. Probability Distributions: Discrete Probability Distributions, Continuous Probability Distributions. Fundamental Sampling Distributions: Sampling Distributions and Data Descriptions, Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S^2, t-Distribution, F-Quantile and Probability Plots. Single Sample & One- and Two-Sample Estimation Problems: Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests). Regression: 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.		
Suggested Instructional/ Reading Material	1. Dimitri P. Bertsekas, John Tsitsiklis, Introduction to probability, Athena Scientific, 2nd Edition, 2008, ISBN: 978-1886529236. 2. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, Cengage Learning, 9th Edition, 2015, ISBN: 978-1305251809. 3. R.E. Walpole, R.H. Myers and S.L. Myers, "Probability and Statistics for Engineers and Scientists", 9th Edition. 4. MIT open courseware: https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/		

Title	Islamic Studies		
Code	GE-196		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide students with a comprehensive overview of the fundamental aspects of Islam, its benefits, practices, history and influence on society. It will further familiarize the students with a solid foundation in understanding Islam from an academic and cultural perspective. Through this course, students will have an enhanced understanding of Islam's multifaceted dimensions which will enable them to navigate complex discussions about Islam's historical and contemporary role, fostering empathy, respect, and informed dialogue.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Demonstrate enhanced knowledge of Islamic foundational beliefs, practices, historical development, fundamental sources of Shiarah, spiritual values and ethical principles.	C1 (Knowledge)	1,7,9,10
	CLO2: Describe basic sources of Islamic law and their application in daily life.	C2 (Understand)	1,7,9,10
	CLO3: Identify and discuss contemporary issues being faced by the Muslim world including social challenges, gender roles and interfaith interactions.	C4 (Analyze)	1,6,7,9,10
Syllabus	1۔ قرآن مجید 1۔ قرآن مجید: معنی و مفہوم، اہمیت و فضیلت، آداب و شرائط تلاوت 2۔ وحی کا معنی و مفہوم، وحی کی اقسام 3۔ قرآن مجید کی جمع و تدوین، حفاظت قرآن 2۔ حدیث نبوی صلی اللہ علیہ وآلہ وسلم 1۔ حدیث کا معنی و مفہوم، اقسام حدیث (قولی - فعلی - تقریری) 2۔ ضرورت و اہمیت حدیث 3۔ مطالعہ حدیث (ترجمہ + تشریح = 4=10 نمبر) 1۔ عن عبد بن حنظلہ لم یروی - اللہ غفۃ کل سخطہ رسول اللہ ﷺ یقول: ہذا الرجل باللیلۃ وہ کلا مرۃ مائتا . فمن کنا فی جہنم لئلا یورسولہ فہجرته لی الذیورسولہ . ومن کنا فی دنیا یجحدہا ، او امرأۃ یرکبہا فہجرته لی ماہاجر الیلۃ (صحیح بخاری: 1) 2۔ عن عجلان بن عبد الرحمن - اللہ غفۃ عن الیہ ﷺ قال: یخرج من تعلّم القرآن وعلمہ (صحیح بخاری: 502) 3۔ عن مالک بن انس یموی - اللہ غفۃ کلّ قال رسول اللہ ﷺ: ترککم فیما تمونین لی تقولوا انتم ستکتھربونا کتاب اللہ بعد موتہ ولہ (رواہ مالک فی الموطا مسند) 4۔ عن عبد اللہ بن عمر رضی اللہ عنہما قال: قال رسول اللہ ﷺ لا یسلم عن حسن شہادۃ کان لکل اللہ ولیّ محمد ابیہ لا یوسد ولہ ولا قلم اللہ لا یولیہم الا کوکب التمجید وضوء رمدہ لی (صحیح مسلم: 113) 5۔ وعن الثعلبی ابن یزید یموی - اللہ غفۃ کلّ قال رسول اللہ ﷺ تری المؤمنین لی ترأثمہم وتوادهم وتعلمہم کمثل حبسہ لما ذاک اللہ یؤیی عدو تک اعی لعنه أبیہم بحسنہ دیا لیسہم ولہم (متفقہ علیہ بخاری: 6011)		

	5۔ خلافتِ راشدہ ۱۔ خلفائے راشدین (حضرت ابو بکر صدیقؓ، حضرت عمر فاروقؓ، حضرت عثمان غنیؓ، حضرت علی المرتضیٰؓ) کے شخصی احوال ۲۔ عہد خلافتِ راشدہ کے اہم خصائص 6۔ فقہِ اسلامی 1۔ فقہِ اسلامی کے مآخذ: (قرآن، سنن، اجماع، قیاس، اجتہاد) 2۔ ائمہ اربعہ کا تعارف (امام ابو حنیفہؒ، امام مالکؒ، امام شافعیؒ، امام احمد بن حنبلؒ) 7۔ اسلام کی سماجی تعلیمات 1۔ خاندان کا تعارف و اہمیت 2۔ اسلام میں عورت کا مقام 3۔ اسلام کا تصور حقوق العباد 4۔ اسلام کی اخلاقی تعلیمات 8۔ اسلام اور جدید دنیا 1۔ عالمِ کتبہ - اور اس کے مسائل و تقاضے 2۔ اسلام و فوج 3۔ کثیر الملکی معاشرہ Pluralistic Society اور اسلامی تعلیمات
Suggested Instructional/ Reading Material	1. "Introduction to Islam" by Dr. Muhammad Hamidullah 2. "Principles of Islamic Jurisprudence" by Dr. Ahmad Hasan 3. "Muslim Jurisprudence and the Quranic Law of Crimes" by Mir Waliullah 4. "Sirat-un-Nabi" by Shibli Nomani and Sulaiman Nadvi

Course Title	Pakistan Studies				
Course Code	GE-194				
Credit Hours	2 (2,0)				
Category	General Education				
Prerequisite	None				
Co-Requisite	None				
Follow-up	GE-195 Ideology and Constitution of Pakistan				
Course Introduction	The course imparts the fundamental knowledge and historical background and political evolution of Muslim society in Indo-Pakistan, including key events and figures leading to the creation of Pakistan.				
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO		
	CLO1: To understand the historical background and political evolution of Muslim society in Indo-Pakistan, including key events and figures leading to the creation of Pakistan.	C2 (Understand)	1		
	CLO2: To analyze Pakistan’s constitutional, administrative, and geopolitical frameworks, along with its cultural and social challenges and international relations.	C4 (Analyze)	2		
	CLO3: To develop skills in independent research, critical evaluation of historical sources, and effective communication through academic writing and presentations.	C5 (Create)	3,4,6		
Syllabus	Historical background of Pakistan: Muslim society in Indo-Pakistan, & Pakistan culture and society, & Pakistan and the challenges ahead. Muslim society in Indo-Pakistan, the movement led by the societies, the downfall of Islamic society, the establishment of British Raj- Causes and consequences. Political evolution of Muslims in the twentieth century: Sir Syed Ahmed Khan; Muslim League; Nehru; Allama Iqbal: Independence Movement; Lahore Resolution; Pakistan culture and society, Constitutional and Administrative issues, Pakistan and its geo-political dimension, Pakistan and International Affairs, Pakistan and the challenges ahead.				
Suggested Instructional/ Reading Material	A. Wynbrandt, James. A Brief History of Pakistan. B. Hayat, Sikandar. Aspects of the Pakistan Movement. National Institute of Historical and Cultural Research. C. Talbot, Ian. Pakistan: A Modern History. D. Khan, Yasmin. Colonial Lahore: A History of the City and Beyond. E. Khan, Hamid. Constitutional and Political History of Pakistan. University of Zulfiqar. F. Ali, Khurram. “K.K. Aziz’s Historiography: A Review on the Making of Pakistan in Perspective of Nationalist Muslims and Muslim Nationalism.” Pakistan Social Sciences Review 4, no. 1 (2020).				
Assessment Plan	Criteria	Marks	CLO1	CLO2	CLO3
	Quizzes	15	8	7	0
	Assignments	08	2	1	5
	Class Participation	02	1	1	0
	Mid Term	35	20	15	0
	Final Term	40	15	15	10
	Total	100	45	30	15

Title	Ideology and Constitution of Pakistan		
Code	GE-195		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding father of Pakistan.	C3 (Demonstrate)	1,10
	CLO2: Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.	C3 (Demonstrate)	1,10
	CLO3: Explain about the guiding principles on rights and responsibilities of Pakistan citizens as enshrined in the Constitution of Pakistan 1973.	C2 (Understand)	1,3,10
Syllabus	Introduction to the Ideology of Pakistan: Definition and significance of ideology, Historical contest of the creation of Pakistan (with emphasis on socio-political religious and cultural dynamics of British India between 1857 till 1947), Contributions of founding fathers of Pakistan of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah., etc. Contributions of women and students in the freedom movement for separate homeland for Muslims of British India. Two-Nation Theory: Evolution of the Two-Nation Theory (Urdu-Hindi controversy, Partition of Bengal, Simla Deputation 1906, Allama Iqbal's Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940). Introduction to the Constitution of Pakistan: Definition and importance of a constitution, Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949). Constitution and State Structure: Structure of Government (executive, legislature, and judiciary), Distribution of powers between federal and provincial governments, 18th Amendment and its impact on federalism. Fundamental Right, Principles of Policy and Responsibilities: Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28), Overview of Principles of Policy (Articles 29-40), Responsibilities of the Pakistan citizens (Article 5). Constitutional Amendments: Procedures for amending the Constitution, Notable Constitutional amendments and their implications		
Suggested Instructional / Reading Material	1. "The Idea of Pakistan" by Stephen P. Cohen. 2. "Ideology of Pakistan" by Javed Iqbal. 3. "The Struggle for Pakistan" by I.H. Qureshi. 4. "Pakistan the Formative Phase" by Khalid Bin Sayeed. 5. "Pakistan: Political Roots and Development" by Safdar Mahmood. 6. "Ideology of Pakistan" by Sharif-ul-Mujahid. 7. "The Struggle for Pakistan: A Muslim Homeland and Global Politics" by Ayesha Jala. 8. "Jinnah, Pakistan and Islamic Identity: The Search for Saladin" by Akbar S. Ahmed. 9. "The Making of Pakistan: A Study in Nationalism" by K.K. Aziz. 10. "Pakistan: A New History" by Lan Talbot. 11. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring. 12. "The Constitution of Pakistan 1973". Original. 13. "Constitutional and Political Development of Pakistan" by Hamid Khan. 14. "The Parliament of Pakistan" by Mahboob Hussain. 15. "Constitutional Development in Pakistan" by G.W. Choudhury. 16. "Constitution-Making in Pakistan: The Dynamics of Political Order" by G.W. Choudhury.		

Title	Fehm-e-Quran-I		
Code	GE-197		
Credit Hours	1 (0, 1)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide students with a fundamental understanding and to develop the ability to understand of the Quran.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understanding the meanings of basic words the Quran, phrases and sentences.	C1 (Remember)	2
	CLO2: Recognize and understand different styles of Quranic sentences.	C2 (Understand)	2, 8
	CLO3: Comprehend Quranic vocabulary, particles (operative & non-operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural), and types of plural through hundreds of Quranic sentences.	C3 (Apply)	2, 10
Syllabus	This course is designed to develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs and sentences having present tense. Acquire a strong foundation for understanding long verses of the Quran with clarity. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plural through hundreds of Quranic sentences. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.		
Suggested Instructional / Reading Material	1. Muallimul Quran by Dr. Ubaidurrahman volume 1,2,3 2. The Holy Quran Translations.		

Title	Fehm-e-Quran-II		
Code	GE-198		
Credit Hours	1 (0, 1)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide students with a fundamental understanding and to develop the ability to understand of the Quran.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understanding the meanings of basic words the Quran, phrases and sentences.	C1 (Remember)	2
	CLO2: Recognize and understand different styles of Quranic sentences.	C2 (Understand)	2, 8
	CLO3: Comprehend Quranic vocabulary, particles (operative & non-operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural), and types of plural through hundreds of Quranic sentences.	C3 (Apply)	2, 10
Syllabus	This course is designed to develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs and sentences having present tense. Acquire a strong foundation for understanding long verses of the Quran with clarity. Comprehend Quranic vocabulary, particles (operative & non operative particles), compounds (Adjective & Possessive compound), pronouns (singular & plural) and types of plural through hundreds of Quranic sentences. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.		
Suggested Instructional / Reading Material	1. Muallimul Quran by Dr. Ubaidurrahman volume 1,2,3 2. The Holy Quran Translations.		

Course Title	Discrete Structures		
Course Code	GE-167		
Credit Hours	3 (3,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.	C2 (Understand)	1,3
	CLO2: Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	C3 (Apply)	1,3
	CLO3: Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C3 (Apply)	1,2,3,4
	CLO4: Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular	C4 (Analyze)	1,2,3,4
Course Description	Mathematical Reasoning: Propositional and predicate logic. Propositional Logic: Logical operators, translations between symbolic expressions and formal English expression, logical equivalences. Predicate Logic: Quantifiers, Nested quantification, equivalences, translations between symbolic forms and formal English. Rules of Inference: Proof methods and strategies, Direct proof, Proof by contraposition, proof by induction, proof by implication, Existence proof, Uniqueness proofs, trivial proofs, vacuous proofs. Sets: Notations, set operations, Venn diagrams, countable and uncountable sets, relations, equivalence relations and partitions, partial orderings, recurrence relations, functions, mappings. Functions: Injective, surjective, bijective, special types of functions, function composition, inverse functions, recursive functions, compositions, number theory, sequences, series, counting, inclusion and exclusion principle, pigeonhole principle, permutations and combinations. Integers and Divisibility: Division theorem, modular arithmetic, LCM, GCD, Euclidean and Extended Euclidean method, finding solutions to congruence. Primes: Fundamental theorem of arithmetic, characterizations of primes, Mersenne primes. Induction: Weak induction, strong induction. Recursion and Recurrences: Formulation of recurrences, closed formulas, Counting: product rule, sum rule, principle of inclusion-exclusion, combinations and permutations, binomial coefficients, Pascal's identity and Pascal's triangle, binomial theorem, pigeonhole principle. Relations: Reflexive, symmetric, transitive, antisymmetric, equivalence relations and equivalence classes, partial orders. Graph Theory: Terminologies, elements of graph theory, planar graphs, graph coloring, Euler graph, Hamiltonian path, rooted trees, traversals, handshaking lemma and corollary, special families of graphs, isomorphism, planarity, Eulerian and Hamiltonian graphs, trees.		
Suggested Instructional/ Reading Material	1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 7th Edition, McGraw Higher-Ed, 2011, ISBN: 0073383090. 2. Susanna S. Epp, Discrete Mathematics with Applications, 4th Edition. 3. Richard Johnson Baugh, Discrete Mathematics, 7th Edition. 4. Kolman, Busby & Ross, Discrete Mathematical Structures, 4th Edition. 5. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition.		

Title	Civics and Community Management		
Code	GE-272		
Credit Hours	2		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide students with fundamental knowledge about civics, citizenship, and community engagement. Students will learn about the essentials of civil society, government, civic responsibilities, inclusivity, and effective ways to participate in shaping the society which will help them apply theoretical knowledge to the real-world situations to make a positive impact on their communities.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Demonstrate fundamental understanding of civics, government, citizenship and civil society.	C3 (Demonstrate)	1
	CLO2: Understand the concept of community and recognize the significance of community engagement for individuals and groups.	C2 (Understand)	1,3,6,7,9,10
	CLO3: Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.	C4 (Identify)	1,6,7,9,10
Syllabus	Introduction to Civics and Citizenship: Definition of civics, citizenship, and civic engagement, Historical evolution of civic participation, Types of citizenship: active, participatory, digital, etc., The relationship between democracy and citizenship. Civics and Citizenship: Concepts of civics, citizenship, and civic engagement, Foundations of modern society and citizenship, Types of citizenship: active, participatory, digital, etc., State, Government and Civil Society: Structure and functions of government in Pakistan, the relationship between democracy and civil society, right to vote and importance of political participation and representation. Rights and Responsibilities: Overview of fundamental rights and liberties of citizens under Constitution of Pakistan 1973, Civic responsibilities and duties, Ethical considerations in civic engagement (accountability, non-violence, peaceful dialogue, civility, etc.) Community Engagement: Concept, nature and characteristics of community, Community development and social cohesion, Approaches to effective community engagement, Case studies of successful community driven initiatives. Advocacy and Activism: Public discourse and public opinion, Role of advocacy in addressing social issues, Social action movements. Digital Citizenship and Technology: The use of digital platforms for civic engagement, Cyber ethics and responsible use of social media, Digital divides and disparities (access, usage, socioeconomic, geographic, etc.) and their impacts on citizenship. Diversity, Inclusion and Social Justice: Understanding diversity in society (ethnic, cultural, economic, political etc.), Youth, women and minorities' engagement in social development, Addressing social inequalities and injustices in Pakistan, Promoting inclusive citizenship and equal rights for societal harmony and peaceful co-existence.		
Suggested Instructional / Reading Material	1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education 2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman. 3. "Engaging Youth in Civic Life" by James Youniss and Peter Levine. 4. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson. 5. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby. 6. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian. 7. "Creating Social Change: A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel.		

Title	Introduction to Management		
Code	GE-170		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to provide a comprehensive overview of organizational management. It covers the diverse roles of managers, the crucial interplay between an organization's mission, its goals, and its detailed objectives, and the impact of both internal and external environmental factors on organizations and how they strategize in response. Students will gain empirical insights into organizational processes, behaviors, and their foundational theories. Emphasis will be placed on honing critical thinking, particularly in addressing ethical dilemmas, global perspectives, and diversity within management functions. Finally, this course sheds light on the intricacies of organizational design and structural challenges, providing a holistic grasp of management dynamics.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the fundamental roles and functions of managers and explain how organizational goals align with internal and external environmental factors.	C2 (Understand)	1, 8
	CLO2: Apply management functions (planning, organizing, leading, and controlling) to solve basic managerial problems in case-based scenarios.	C3 (Apply)	2, 3
	CLO3: Evaluate management strategies and organizational structures in terms of their effectiveness in addressing change, innovation, ethical concerns, and cultural diversity.	C5 (Evaluate)	4, 8, 9
Course Contents / Syllabus	Managing and the Managers Job: The management process, kinds of managers, basic managerial roles and skills, and the nature of managerial work. The Environment and Culture of Management: The external and internal environment, the organization's cultures, organization-environment relationship. Planning and Decision Making: Decision making and planning process, organizational goals and levels of planning, various levels of strategies, rational perspectives on decision making, behavioral aspects of decision making, group and team decision making in organizations. The Organizing Process: Designing Jobs, grouping jobs, establishing reporting relationships, distributing authority, coordinating activities. Managing Change and Innovation: Forces for change, steps in the change process, understanding and overcoming resistance to change, the innovation process. Leadership and Influence Process: Different approaches to leadership, political behavior in organizations. Managing Effective Communication: The communication process, barriers to effective communication. The Controlling Process: The purpose of control, steps in the control process; operational, structural, and strategic control, managing total quality and productivity. The Ethical and Social Environment: Individual ethics in organization, emerging ethical issues, social responsibility and organizations.		
Suggested Instructional/ Reading Material	1. Ricky W. Griffin, Management, 12th Edition, Cengage Learning, 2017, ISBN: 1305501292. 2. Stephen P Robbins, Mary Coulter, Management, 14th Edition, Pearson, 2017, ISBN: 0134527607.		

Course Title	Professional Practices		
Course Code	GE-270		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	A computing graduate as a professional has some responsibilities with respect to society. This course develops student understanding of historical, social, economic, ethical, and professional issues related to the discipline of computing. It identifies key sources for information and opinions about professionalism and ethics. Students analyze, evaluate, and assess ethical and professional computing case studies.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand fundamental ethical theories, professional responsibilities, and key provisions of software engineering codes of ethics.	C2 (Understand)	1, 9
	CLO2: Apply ethical frameworks and professional codes of conduct to analyze and resolve real-world dilemmas in software engineering and IT practice.	C3 (Apply)	3, 8, 9
	CLO3: Evaluate complex professional scenarios involving privacy, intellectual property, and software liability by comparing competing ethical principles and legal standards.	C5 (Evaluate)	4, 8, 9
Course Contents / Syllabus	Historical, social, and economic context of computing (software engineering, computer science, information technology, and so on); the paradigm of professions, sorting out computing and its status as a profession, ethics and some fundamental ethical viewpoints (utilitarianism, deontological theories, rights, virtue ethics). The ethical judgment of moral dilemmas (the ethical cycle), 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. Hacking and hackers' ethics, identity theft, privacy, 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, and the ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and auditing, computer applications in various sectors along with ethical dilemmas.		
Suggested Instructional/ Reading Material	A. Michael J. Quinn, Ethics for the Information Age, 7th Edition, Pearson Education, 2017, ISBN: 978-0134296548 B. Sara Baase, A Gift of Fire: Social, Legal, and Ethical Issues in Computing, 5th Edition, Pearson, 2018, ISBN: 978-0132492676 C. George W. Reynolds, Ethics in Information Technology, 5th Edition, Cengage Learning, 2015, ISBN: 978-1285197159 D. Poel, van de, I. R., & Royakkers, L. M. M. (2007). The ethical cycle. Journal of Business Ethics, 71(1), 1-13. E. "Professional Issues in Software Engineering" by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, 3rd Edition, CRC Press, 2000. ISBN-10: 0748409513		

Course Title	Entrepreneurship		
Code	GE-271		
Credit Hours	2 (2,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge; skills and abilities, enabling them seize the identified opportunities for initiating of business (including requirements for registration and incorporation with regulators such as SECP and others), market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation, overall, the course is geared towards personal growth and professional development for pursuing innovative ideas, availing opportunities and initiating start-ups.		
Course Learning Outcomes (CLOs)	On completion of this course, the students will be able to:	BT	PLO
	CLO1: Understand key entrepreneurial concepts, including the different stages of the entrepreneurial process as well as specific regulatory requirements to set up an enterprise in Pakistan.	C2 (Understand)	1, 8
	CLO2: Apply entrepreneurial frameworks and techniques to identify business opportunities and use this knowledge to produce practical solutions to real-world startup challenges.	C3 (Apply)	2, 3, 4
	CLO3: Develop a comprehensive business plan for a new venture by analyzing the feasibility of a new business idea and by justifying the proposed strategies.	C6 (Create)	3, 4, 7, 10
Course Contents / Syllabus	Introduction: Definition and concept of entrepreneurship, why to become an entrepreneur? Entrepreneurial process, Role of entrepreneurship in economic development. Entrepreneurial Skills: Characteristics and qualities of successful entrepreneurs (including stories of successes and failures), Areas of essential entrepreneurial skills and abilities. Opportunity Recognition and Idea Generation: Opportunity identification, evaluation and exploitation, Innovative ideas generation techniques for entrepreneurial ventures. Feasibility Analysis: Product/Service, Industry/Target Market, Organizational, and Financial Feasibility Analysis. Business Models: General Categories of Business Models, The Barringer/Ireland Business Model Template. Industry and Competitor Analysis: The Five Forces Model, Industry types and the opportunities they offer, Competitor analysis. The Business Plan: Who reads it and what are they looking for? Guidelines and outline, Presenting it to investors. Marketing and sales: Four P's of Marketing, Developing a marketing strategy, Branding. Financial Literacy: Basic concepts of income, savings, investments, assets, liabilities, equity, revenue and expenses, Overview of financial statements (balance sheet, profit & loss, cash flow), Getting Financing or Funding: Sources of personal financing, Sources of equity funding, Sources of debt financing, Creative sources of financing and funding. Team Building for Startups: Characteristics and features of effective teams, Team building and effective leadership for startups. Regulatory Requirements to Establish Enterprises in Pakistan: Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.), Intellectual property rights and protection, Regulatory requirements to register an enterprise in Pakistan, with special emphasis on exports firms, Taxation and financial reporting obligation.		
Textbook	1. B. R. Barringer, and R. D. Ireland, Entrepreneurship: Successfully Launching New Ventures, 6th Edition, Prentice Hall, 2019, ISBN: 978-0134729534.		
Suggested Instructional/ Reading Material	1. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko. 2. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams. 3. "Entrepreneurship: A Real-World Approach" by Rhonda Abrans. 4. "The Lean Startup: How Today's Entrepreneurs use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries. 5. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valcric Ohlsson.		

3) AI Specialization Electives

Course Title	Programming for Artificial Intelligence (AI)		
Course Code	EA-320		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	Object Oriented Programing, Artificial Intelligence		
Co-Requisite	None		
Follow-up	Deep Learning		
Course Introduction	This course aims to provide students with a comprehensive foundation in programming for AI and practical experience in applying AI techniques and methods to real-world problems. Emphasis is placed on hands-on programming and project work, as well as critical thinking and problem-solving skills. By the end of the course, students will have the knowledge and skills needed to pursue further studies and careers in the field of Artificial Intelligence.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Write efficient and well-documented code.	C3 (Apply)	2,3,4
	CLO2: Utilize version control (Git) to manage and collaborate on AI-related code repositories.	C3 (Apply)	5,6
	CLO3: Implement basic Machine Learning models using standard ML frameworks	C5 (Create)	4,5,6
	CLO4: Implement and evaluate machine learning and basic neural network models for solving real-world problems.	C3 (Apply),	3,4,5
	CLO5: Use version control tools (e.g., Git) and collaborative practices in AI-based software development.	C3 (Apply)	5,6
	CLO6: Design and develop AI-based solutions through projects, demonstrating problem-solving, critical thinking, and communication skills.	C5 (Create)	3,4,5,6
Syllabus	Introduction to Python language, Variables, Data types, Control Structures, Procedures and Classes. Introduction to the Python libraries and packages: NumPy and Pandas for data processing; Matplotlib, Seaborn and Plotly for exploratory data analysis and visualization; Sklearn for machine learning models; PyTorch, Tensorflow and Tensorboard for neural network models.		
Suggested Instructional/ Reading Material	1. Staring out with Python by Tony Gaddis, 5th Edition, Pearson, ISBN: 978-0-13-592903-2 2. Hands-on machine learning with scikit-learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems, 2nd Edition, Géron, A., 2019, O'Reilly Media. ISBN: 978-1492032649 3. Deep Learning with PyTorch, Stevens, E., Antiga, L., & Viehmann, T., 2020, Manning Publications, ISBN: 978-1617295263 4. Interactive data visualization with Python: Create interactive plots with Plotly, Bokeh, and Dash in Python, Belorkar, A., 2023, 2nd Edition, Packt Publishing, ISBN: 978-1804615656		

Title	Machine Learning		
Code	EA-321		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	CC-218 Artificial Intelligence		
Co-Requisite			
Follow-up			
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.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain fundamental concepts, paradigms, and algorithms of machine learning, including supervised and unsupervised learning.	C2 (Understand)	1,2
	CLO2: Implement and fine-tune supervised and unsupervised machine learning models to solve real-world problems.	C3 (Apply)	2,3,4
	CLO3: Analyze the performance of ML models using evaluation metrics.	C4 (Analyze)	2,3,4
	CLO4: Implement ML solutions using modern toolkits.	C3 (Apply)	2,3,4
	CLO5: Design and conduct machine learning experiments, including model development, validation, and iterative improvement.	C5 (Create)	3,4,5,6
	CLO6: Evaluate and compare machine learning models to select optimal solutions for specific tasks.	C6 (Evaluate)	3,4,5,6
Syllabus	Topics: Machine learning course begins with foundational concepts, such as understanding supervised and unsupervised learning, feature engineering, and model evaluation techniques. As the course progresses, students delve into various supervised machine learning algorithms, including linear and nonlinear regression, logistic regression, decision trees, random forest, support vector machines, and neural networks. For each of the aforementioned algorithms, students learn about their hypothesis functions, cost functions, optimization functions and regularization techniques to avoid overfitting. The topics related to unsupervised machine learning are also part of the course. The students learn clustering techniques such as k-mean's clustering, and dimensionality reduction algorithms like principal component analysis and auto-encoders. Implementation of the theoretical concepts using Python, Different libraries and frameworks such as NumPy, Pandas, Scikit Learn and TensorFlow, Libraries for supervised and unsupervised machine learning algorithms such as linear and nonlinear regression, logistic regression, decision trees, random forest, support vector machines, neural networks (forward and backward propagation), k-mean's clustering, and dimensionality reduction algorithms like principal component analysis and auto-encoders. Publicly available datasets are used for practical demonstration of the aforementioned algorithms.		
Suggested Instructional/ Reading Material	1. Introduction to Machine Learning by Ethem Alpaydin 2. The Hundred-Page Machine Learning Book by Andriy Burkov 3. Hands On Machine Learning with Scikit Learn, Keras and TensorFlow 2e by Aurélien Géron 4. Deep Learning with Python by François Chollet 5. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville		

Course Title	Deep Learning		
Course Code	EA-322		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	EA-320: Programming for AI		
Co-Requisite	None		
Follow-up			
Course Introduction	This course introduces the foundational principles and techniques of Artificial Neural Networks (ANNs) and Deep Learning. Students will explore the design and implementation of neural network models to solve complex real-world problems. Topics include supervised and unsupervised learning, convolutional and recurrent networks, optimization strategies, and emerging deep learning architectures. Hands-on exercises and projects will enhance students' understanding and practical skills in developing deep learning solutions.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain the theoretical foundations of neural networks and their role in machine learning.	C2 (Understand)	1
	CLO2: Analyze and evaluate different architectures of artificial neural networks for specific applications.	C4 (Analyze)	2,3
	CLO3: Design and implement deep learning models using modern frameworks like TensorFlow or PyTorch.	C5 (Design)	4,5,7
	CLO4: Apply optimization techniques to improve the performance of neural network models.	C3 (Apply)	3, 5
	CLO5: Develop solutions to real-world problems using deep learning methodologies.	C5 (Design)	4,7,10
Syllabus	Introduction to Artificial Neural Networks: Biological inspiration, perceptrons, activation functions, feedforward networks. Learning and Optimization: Gradient descent, backpropagation, loss functions, regularization techniques. Deep Neural Networks: Architecture, vanishing and exploding gradients, optimization strategies. Convolutional Neural Networks (CNNs): Layers, feature extraction, applications in image processing. Recurrent Neural Networks (RNNs) and Variants: LSTMs, GRUs, applications in sequential data processing. Unsupervised Learning with Autoencoders: Denoising, dimensionality reduction. Generative Models: Variational autoencoders (VAEs), Generative Adversarial Networks (GANs). Advanced Topics: Transformers, attention mechanisms, ethical considerations in AI. Practical Applications: Case studies in healthcare, finance, and other domains.		
Suggested Instructional/ Reading Material	1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, <i>Deep Learning</i>, MIT Press. 2. François Chollet, <i>Deep Learning with Python</i>, Manning Publications. 3. Michael Nielsen, <i>Neural Networks and Deep Learning</i>. 4. Hands-on documentation and tutorials from TensorFlow and PyTorch.		

Course Title	Knowledge Representation and Reasoning		
Course Code	EA-323		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite			
Co-Requisite	None		
Course Introduction	Knowledge representation is one of the fundamental areas of Artificial Intelligence. It is the study of how knowledge about the world can be represented and manipulated in an automated way to enable agents to make intelligent decisions. This course will provide an overview of existing knowledge representation frameworks developed within AI including but not limited to propositional and first-order logic, ontologies, planning, reasoning and decision making under uncertainty. The assignments component of the course would provide hands-on experience of software like Prolog, Protégé, probabilistic reasoning APIs and tools to support complex decision making. It is expected that after completing this course, students will understand (a) the foundations of Knowledge Representation & Reasoning and (b) which tools and techniques are appropriate for which tasks.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO-1 Explain the fundamental concepts of knowledge representation and reasoning in both deterministic and uncertain environments.	C2 (Understand)	1,2
	CLO-2 Analyze different problem scenarios and select appropriate knowledge representation techniques such as semantic networks, frames, and logical formalisms.	C4 (Analyze)	1,2,3,4,5
	CLO-3 Apply reasoning and inference mechanisms (e.g., rule-based systems, logical inference) to solve AI problems.	C3 (Apply)	3,4,5,7
	CLO-4 Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems	C4 (Analyze)	2,3,4,5,7
	CLO-5 Implement knowledge-based systems using logic programming tools such as Prolog.	C3 (Apply)	3,4,5
Syllabus	Propositional Logic, First-order Logic, Horn Clauses, Description Logic, Reasoning using Description Logic, Forward and Backward Chaining in Inference Engines, Semantic Networks, Ontologies and Ontology Languages, Logical Agents, Planning, Rule-based Knowledge Representation, Reasoning Under Uncertainty, Bayesian Networks Representation, Inference in Bayesian Networks, Fuzzy Logic, Inference using Fuzzy Rules, Markov Models, Commonsense Reasoning, Explainable AI.		
Suggested Instructional/ Reading Material	1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (4th Ed.) 2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 3rd Ed, 2023 3. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning, 2004		

Course Title	Computer Vision		
Course Code	EA-325		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	EA-322: Deep Learning		
Co-Requisite	None		
Follow-up	None		
Course Introduction	The course focuses on the fundamentals and advancements in computer vision, enabling students to analyze and interpret visual data from images and videos. It covers essential topics, including image processing, feature extraction, object detection, and tracking. Emphasis is placed on designing and implementing computer vision systems to solve real-world problems. Students will also explore recent advancements, including convolutional neural networks and their applications in computer vision tasks.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain the basic concepts and challenges of computer vision.	C2 (Understand)	1
	CLO2: Analyze and implement fundamental image processing techniques.	C3 (Apply)	2,5
	CLO3: Design algorithms for feature extraction and pattern recognition in images and videos.	C5 (Design)	4,5,7
	CLO4: Evaluate modern techniques for object detection, recognition, and segmentation.	C3 (Analyze)	2,3
	CLO5: Apply deep learning techniques to solve complex computer vision tasks.	C5 (Appl)	3, 4, 10
Syllabus	Introduction to Computer Vision: Scope, challenges, and applications of computer vision. Image Formation and Representation: Camera models, image formation, and color spaces. Image Processing Fundamentals: Filtering, edge detection, interest point detection, and image transformations. Feature Extraction and Matching: Keypoint descriptors, feature matching, and homography estimation. Object Detection and Recognition: Viola-Jones, HOG, and deep learning-based object detection (YOLO, SSD). Image Segmentation: Thresholding, region-based segmentation, and semantic segmentation using deep learning. Motion and Tracking: Optical flow, tracking algorithms (e.g., Kalman filter, mean-shift, and deep trackers). 3D Computer Vision: Stereo vision, depth estimation, and 3D reconstruction. Deep Learning in Computer Vision: Convolutional neural networks (CNNs), transfer learning, and pre-trained models (ResNet, VGG). Applications and Case Studies: Real-world applications in autonomous vehicles, medical imaging, and surveillance.		
Suggested Instructional/ Reading Material	1. Richard Szeliski, <i>Computer Vision: Algorithms and Applications</i>, Springer. 2. Adrian Rosebrock, <i>Practical Python and OpenCV</i>, PyImageSearch. 3. Gary Bradski and Adrian Kaehler, <i>Learning OpenCV 3: Computer Vision in C++ with the OpenCV Library</i>. 4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, <i>Deep Learning</i>, MIT Press. 5. Documentation and tutorials for OpenCV, TensorFlow, and PyTorch.		

Course Title	Game Design and Development		
Course Code	EA-324		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	CC-211: Object Oriented Programming		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course provides a comprehensive exploration of game creation, focusing on the principles of design and development. It covers programming, art creation, music, and animations, utilizing tools such as Unity 3D and various graphic and sound design software. The curriculum includes the application of mathematics, physics, and artificial intelligence to game development, addressing porting challenges across different platforms. The course emphasizes hands-on experience and team collaboration, preparing students with the skills and knowledge necessary to create engaging and innovative games. The course will cover basic game development tools, such as Unity 3D, Spriter, Inkscape, and Magicavoxel, and their effective use in creating game assets.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain the fundamental principles of game design and development.	C2 (Understand)	1,2
	CLO2: Identify the roles and responsibilities within a game development team.	C2 (Understand)	1,2
	CLO3: Apply programming skills to develop interactive games.	C2 (Understand)	1,2
	CLO4: Create game assets, including art, music, and animations, using various tools.	C2 (Understand)	1,2
	CLO5: Implement mathematical and physical concepts in game mechanics.	C3 (Apply)	3,4,5
	CLO6: Implement basic artificial intelligence and simulation in game development.	C3 (Apply)	3,4,5
Syllabus	Introduction to Game Development and Design. Game Development Tools: Unity 3D for game creation, Spriter for animations, Inkscape for vector graphics, and Magicavoxel for voxel art. Game Design Process: Paper prototyping, agile development, and iterative design. Game Art and Animation: Techniques for creating 2D art and animations, focusing on pixel art, voxels, and vector graphics. Tools and methods for designing user interfaces, color palettes, and atmospheric elements. Music and Sound Design: Basics of music and sound creation, setting up the mood, and integrating audio elements into games. Tools for creating digital music and sound effects. Artificial Intelligence in Games: Application of basic artificial intelligence concepts to develop more dynamic and engaging game experiences. Understanding the role of AI in game mechanics and player interaction. Platform Porting: Challenges of porting games to multiple platforms. Strategies for adapting game content and functionality across different devices. Team Collaboration and Project Management, Ethical and Legal Considerations.		
Suggested Instructional/ Reading Material	1. Game Programming Patterns by Robert Nystrom - (2014) - ISBN-13: 978-0992252902 2. The Art of Game Design: A Book of Lenses by Jesse Schell - 3rd Edition (2020) - ISBN-13: 978-0367338846 3. Rules of Play: Game Design Fundamentals by Katie Salen and Eric Zimmerman - (2004) - ISBN-13: 978-0262240451 4. The Game Design Workshop: A Playcentric Approach to Creating Innovative Games by Tracy Fullerton - 3rd Edition (2021) - ISBN-13: 978-0367337955 5. Level Up! The Guide to Great Video Game Design by Scott Rogers - (2010) - ISBN 13: 978-0470688677 6. Game Feel: A Game Designer's Guide to Virtual Sensation by Steve Swink - (2008) - ISBN-13: 978-0123743287 7. Designing Games: A Guide to Engineering Experiences*** by Tynan Sylvester - (2013) - ISBN-13: 978-0124114962		

Course Title	Natural Language Processing		
Course Code	EA-326		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	EA-322: Deep Learning		
Co-Requisite	None		
Course Introduction	Natural Language Processing (NLP) is the application of computational techniques to the analysis and synthesis of natural language and speech. This course is an introduction to NLP with prior programming experience in Python.		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	BT	PLO
	CLO1: Understand techniques for information retrieval, language translation, and text classification	C2 (Understand)	2,3,4,5
	CLO2: Understand the advantages of using standard corpora	C2 (Understand)	2,3,4,5
	CLO3: Identify examples of current corpora for a variety of NLP tasks	C2 (Understand)	2,3,4,5,7
	CLO4: Solve classic and stochastic algorithms for parsing natural language.	C3 (Apply)	2,3,4,5
	CLO5: Implement IR systems	C3 (Apply)	2,3,4,5,7
Syllabus	Introduction & History of NLP, Parsing algorithms, Basic Text Processing, Minimum Edit Distance, Language Modeling, Spelling Correction, Text Classification, Deterministic and stochastic grammars, CFGs, Representing meaning /Semantics, Semantic roles, Semantics and Vector models, Sentiment Analysis, Temporal representations, Corpus-based methods, N-grams and HMMs, Smoothing and backoff, POS tagging and morphology, Information retrieval, Vector space model, Precision and recall, Information extraction, Relation Extraction (dependency, constituency grammar), Language translation, Text classification, categorization, Bag of words model, Question and Answering, Text Summarization		
Suggested Instructional/ Reading Material	1. Daniel Jurafsky and James H. Martin. 2018. Speech and Language Processing: An Introduction to Natural Language Processing. Third Edition. Prentice Hall 2. Foundations of Statistical Natural Language Processing, Manning and Schütze, MIT Press. Cambridge, MA: May 1999		

Course Title	Agent-Based Modeling		
Course Code	EA-425		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	Artificial Intelligence		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Agent-Based Modeling (ABM) is a computational method used to study complex systems by modeling them as a collection of individual entities, known as agents, which interact within a given environment. These agents operate based on predefined rules, allowing for the emergence of complex behaviors and phenomena. This course introduces the foundations of ABM, focusing on key concepts, techniques, and applications in diverse domains such as economics, biology, sociology, and artificial intelligence. Through hands-on assignments and projects, students will use tools like NetLogo, Repast, and Python libraries to design, simulate, and analyze agent-based models. By the end of the course, students will be equipped to use ABM for research and practical problem-solving in various fields.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the fundamental concepts and principles of agent-based modeling.	C2 (Understand)	1,2
	CLO2: Analyze and design agent-based models for real-world problems.	C4 (Analyzing)	3, 4, 5
	CLO3: Implement agent-based models using modern tools and programming environments.	C3 (Applying)	3, 4, 5
	CLO4: Evaluate the outcomes of simulations and refine models for improved accuracy and scalability.	C5 (Creating)	3, 4, 5
Syllabus	The course begins with an Introduction to Agent-Based Modeling (ABM), covering its definition, key concepts like agents, environments, and interactions, and exploring its diverse applications across domains. Next, students will delve into Modeling Frameworks and Tools, gaining hands-on experience with platforms such as NetLogo, Repast, and Python libraries like Mesa, while setting up simple ABMs. In Agent Design and Rules, the focus shifts to defining agents' attributes and states, creating interaction rules, and understanding emergent behaviors in complex systems. The Simulations and Dynamics section introduces running simulations, time-stepped vs. event-driven models, and conducting sensitivity analysis. Real-world applications of ABM are explored in Applications of ABM, including social systems, biological models, and economic scenarios. The Validation and Calibration module emphasizes verifying models, comparing outputs to real-world data, and fine-tuning parameters. Advanced Topics in ABM cover multi-agent systems, hybrid modeling approaches, and scalability challenges. Finally, students will engage with Case Studies and Projects, analyzing notable ABM implementations and designing their own simulations to solve specific problems.		
Suggested Instructional/ Reading Material	1. Nigel Gilbert, "Agent-Based Models," SAGE Publications, 2008. 2. Uri Wilensky and William Rand, "An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo," MIT Press, 2015. 3. Steven F. Railsback and Volker Grimm, "Agent-Based and Individual-Based Modeling: A Practical Introduction," Princeton University Press, 2011. 4. Benjamin R. Sabathé, "Agent-Based Modelling of Socio-Technical Systems," Springer, 2018.		

Course Title	Generative Artificial Intelligence		
Course Code	EA-328		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	Artificial Intelligence		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Generative Artificial Intelligence (Generative AI) is a rapidly evolving field of artificial intelligence focused on creating models capable of generating new content such as text, images, audio, and code. These models learn underlying patterns from data and use this knowledge to produce realistic and meaningful outputs. This course introduces the foundational concepts, architectures, and techniques of Generative AI, including Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), diffusion models, and large language models (LLMs). The course emphasizes both theoretical understanding and practical implementation. Students will explore how generative models are trained, evaluated, and fine-tuned for real-world applications such as content generation, data augmentation, conversational AI, and creative design. Through hands-on assignments and projects, students will use modern tools and frameworks such as PyTorch, TensorFlow, and transformer-based libraries to build and experiment with generative systems. In addition, the course addresses important ethical, societal, and security considerations associated with Generative AI, including bias, misinformation, intellectual property, and responsible deployment. By the end of the course, students will be equipped with the knowledge and skills to design, implement, and critically evaluate generative AI solutions for research and industry applications.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Describe the foundational concepts, models, and architectures of Generative AI, including GANs, VAEs, and large language models.	C2 (Understand)	1,2
	CLO2: Implement and fine-tune generative models using modern AI frameworks such as TensorFlow or PyTorch.	C3 (Apply)	3, 4, 5
	CLO3: Analyze the ethical, societal, and practical implications of deploying Generative AI in real-world applications.	C4 (Analyze)	3, 4, 5
	CLO4: Design and develop a generative AI-based solution for a real-world problem, integrating appropriate models, evaluation techniques, and deployment considerations.	C5 (Creating)	3, 4, 5
Syllabus	The course begins with an Introduction to Generative AI, covering the definition, scope, and significance of generative models in modern artificial intelligence. Students will explore different types of generative approaches and their applications in text, image, audio, and multimodal domains. Next, students will study the Foundations of Generative Modeling, including probability distributions, latent variable models, likelihood estimation, and basic concepts required to understand generative processes. This module builds the mathematical intuition behind generative techniques. In Variational Autoencoders (VAEs), students will learn about encoder-decoder architectures, latent space representations, variational inference, and reconstruction loss. Practical implementation of VAEs for data generation and representation learning will also be covered. The course then moves to Generative Adversarial Networks (GANs), focusing on adversarial training, generator and discriminator architectures, loss functions, and common challenges such as mode collapse and training instability. Variants like DCGAN and conditional GANs will also be introduced. In Diffusion Models and Modern Generative Techniques, students will explore denoising diffusion probabilistic models (DDPMs), score-based generative modeling, and their applications in high-quality image synthesis. The Large Language Models (LLMs) and Transformer-based Generation module introduces transformer architectures, attention mechanisms, pretraining and fine-tuning strategies, and applications in text generation, chatbots, and code generation. The Evaluation and Optimization of Generative Models module covers metrics such as BLEU, ROUGE, FID, perplexity, and human evaluation techniques. Students will also learn about hyperparameter tuning and model optimization strategies. In Applications of Generative AI, students will explore real-world use cases including content generation, data		

	augmentation, conversational AI, healthcare applications, and creative AI systems. The Ethics, Safety, and Societal Impact module addresses challenges such as bias, fairness, hallucination, misinformation, intellectual property, and responsible AI deployment. Advanced topics in Generative AI include multimodal models, generative AI for time-series and sensor data (relevant to your domain), and emerging trends such as foundation models and generative agents. Finally, students will engage in Case Studies and Projects, where they will analyze state-of-the-art generative systems and design their own applications using tools such as PyTorch, TensorFlow, and transformer-based libraries.
Suggested Instructional/ Reading Material	1. Deep Learning: Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016. (Foundational reference; includes GANs and representation learning basics) 2. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 2006. (Covers probabilistic models and latent variable methods relevant to VAEs) 3. Generative Deep Learning, David Foster, O'Reilly Media, 2nd Edition, 2022. (Practical guide covering VAEs, GANs, transformers, and diffusion models) 4. Hands-On Machine Learning with Scikit-Learn Keras and TensorFlow, Aurélien Géron, O'Reilly Media, 3rd Edition, 2022. (Includes practical implementations of generative models and deep learning pipelines) 5. Natural Language Processing with Transformers, Lewis Tunstall, Leandro von Werra, Thomas Wolf, O'Reilly Media, 2022. (Hands-on resource for transformer-based generative models and LLMs)

Course Title	Reinforcement Learning		
Course Code	EA-422		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	Artificial Intelligence		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Reinforcement Learning (RL) is a branch of artificial intelligence that focuses on how intelligent agents learn to make decisions by interacting with an environment and receiving feedback in the form of rewards or penalties. Unlike supervised learning, where models learn from labeled data, reinforcement learning emphasizes sequential decision-making, trial-and-error learning, and long-term reward optimization. RL has been successfully applied in diverse domains such as robotics, game playing, recommendation systems, finance, and autonomous systems. This course introduces the foundational principles of reinforcement learning, including Markov Decision Processes (MDPs), value functions, policies, and exploration–exploitation trade-offs. Students will study key algorithms such as dynamic programming, Monte Carlo methods, temporal-difference learning, Q-learning, and policy gradient methods. The course also explores the integration of deep learning with reinforcement learning, enabling agents to operate in complex, high-dimensional environments. Through hands-on assignments and projects, students will implement reinforcement learning algorithms using modern frameworks such as Python-based libraries, and apply them to simulated and real-world problems. The course further addresses practical challenges such as scalability, stability, and sample efficiency, along with evaluation techniques for comparing different RL approaches. By the end of the course, students will be equipped with the knowledge and skills to design, implement, and evaluate reinforcement learning solutions for complex decision-making tasks, as well as to understand their limitations and real-world implications.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the core components of Markov Decision Processes and Reinforcement Learning.	C2 (Understand)	1,2
	CLO2: Implement reinforcement learning algorithms to model and solve dynamic environments.	C3 (Apply)	3, 4, 5
	CLO3: Evaluate reinforcement learning approaches in terms of performance, scalability, and applicability to real-world domains.	C5 (Evaluate)	3, 4, 5
	CLO4: Design and develop reinforcement learning-based solutions for complex decision-making problems in real-world scenarios.	C6 (Creating)	3, 4, 5
Syllabus	The course begins with an Introduction to Reinforcement Learning, covering basic concepts such as agents, environments, rewards, and applications. It then moves to the Foundations of Reinforcement Learning, including Markov Decision Processes (MDPs), policies, value functions, and Bellman equations. The Dynamic Programming module covers policy evaluation, policy iteration, and value iteration. In Model-Free Reinforcement Learning, students study Monte Carlo methods, Temporal-Difference learning, SARSA, and Q-learning, along with exploration–exploitation strategies. The course introduces Function Approximation and Deep Reinforcement Learning, including neural networks, Deep Q-Networks (DQN), and stability techniques. This is followed by Policy Gradient and Actor-Critic Methods, focusing on gradient-based learning approaches. The syllabus also includes Evaluation and Optimization of RL Models, covering performance metrics and tuning techniques. In Applications of Reinforcement Learning, students explore real-world use cases such as robotics, games, and recommendation systems. Advanced topics include multi-agent reinforcement learning and hierarchical reinforcement learning. The course concludes with Case Studies and Projects, where students design and implement reinforcement learning solutions.		
Suggested Instructional/ Reading Material	1. Reinforcement Learning An Introduction, Richard S. Sutton, Andrew G. Barto, MIT Press, 2nd Edition, 2018. 2. Algorithms for Reinforcement Learning, Csaba Szepesvári, Morgan & Claypool, 2010. 3. Deep Reinforcement Learning Hands-On, Maxim Lapan, Packt, 2nd Edition, 2020. 4. Hands-On Machine Learning with Scikit-Learn Keras and TensorFlow 5. Aurélien Géron, O'Reilly, 3rd Edition, 2022.		

Course Title	Agentic Artificial Intelligence (AI)		
Course Code	EA-421		
Credit Hours	3 (2,1)		
Category	AI Specialization Elective		
Prerequisite	Programming for Artificial Intelligence		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Reinforcement Learning (RL) is a branch of artificial intelligence that focuses on how intelligent agents learn to make decisions by interacting with an environment and receiving feedback in the form of rewards or penalties. Unlike supervised learning, where models learn from labeled data, reinforcement learning emphasizes sequential decision-making, trial-and-error learning, and long-term reward optimization. RL has been successfully applied in diverse domains such as robotics, game playing, recommendation systems, finance, and autonomous systems. This course introduces the foundational principles of reinforcement learning, including Markov Decision Processes (MDPs), value functions, policies, and exploration–exploitation trade-offs. Students will study key algorithms such as dynamic programming, Monte Carlo methods, temporal-difference learning, Q-learning, and policy gradient methods. The course also explores the integration of deep learning with reinforcement learning, enabling agents to operate in complex, high-dimensional environments. Through hands-on assignments and projects, students will implement reinforcement learning algorithms using modern frameworks such as Python-based libraries, and apply them to simulated and real-world problems. The course further addresses practical challenges such as scalability, stability, and sample efficiency, along with evaluation techniques for comparing different RL approaches. By the end of the course, students will be equipped with the knowledge and skills to design, implement, and evaluate reinforcement learning solutions for complex decision-making tasks, as well as to understand their limitations and real-world implications.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand the core components of Markov Decision Processes and Reinforcement Learning.	C2 (Understand)	1,2
	CLO2: Implement reinforcement learning algorithms to model and solve dynamic environments.	C3 (Apply)	3, 4, 5
	CLO3: Evaluate reinforcement learning approaches in terms of performance, scalability, and applicability to real-world domains.	C (Evaluate)	3, 4, 5
	CLO4: Design and develop reinforcement learning-based solutions for complex decision-making problems in real-world scenarios.	C5 (Creating)	3, 4, 5
Syllabus	The course begins with an Introduction to Reinforcement Learning, covering basic concepts such as agents, environments, rewards, and applications. It then moves to the Foundations of Reinforcement Learning, including Markov Decision Processes (MDPs), policies, value functions, and Bellman equations. The Dynamic Programming module covers policy evaluation, policy iteration, and value iteration. In Model-Free Reinforcement Learning, students study Monte Carlo methods, Temporal-Difference learning, SARSA, and Q-learning, along with exploration–exploitation strategies. The course introduces Function Approximation and Deep Reinforcement Learning, including neural networks, Deep Q-Networks (DQN), and stability techniques. This is followed by Policy Gradient and Actor-Critic Methods, focusing on gradient-based learning approaches. The syllabus also includes Evaluation and Optimization of RL Models, covering performance metrics and tuning techniques. In Applications of Reinforcement Learning, students explore real-world use cases such as robotics, games, and recommendation systems. Advanced topics include multi-agent reinforcement learning and hierarchical reinforcement learning. The course concludes with Case Studies and Projects, where students design and implement reinforcement learning solutions.		
Suggested Instructional/ Reading Material	1. Reinforcement Learning An Introduction, Richard S. Sutton, Andrew G. Barto, MIT Press, 2nd Edition, 2018. 2. Algorithms for Reinforcement Learning, Csaba Szepesvári, Morgan & Claypool, 2010. 3. Deep Reinforcement Learning Hands-On, Maxim Lapan, Packt, 2nd Edition, 2020. 4. Hands-On Machine Learning with Scikit-Learn Keras and TensorFlow 5. Aurélien Géron, O'Reilly, 3rd Edition, 2022.		

Course Title	Cloud Infrastructure and Services		
Course Code	EA-339		
Credit Hours	3 (2,1)		
Category	Specialization Elective		
Prerequisite	CC-113: Computer Networks		
Co-Requisite	None		
Follow-up	None		
Course Introduction	Nowadays cloud computing becomes popular for individuals' users as well as for the business community. It provides on-demand huge computation and storage resources which is attractive for a large number of users mainly due to pay-per-usage charging model. This course will introduce topics related to Cloud Computing and also expose students to the latest tools and technologies used in Cloud Computing. The aim of this course is to provide an in-depth knowledge of Cloud Computing topics. The course would also expose students to important methods and tools used Cloud Computing.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain Cloud computing, virtualization, Dockers and scalable web applications.	C2 (Explain)	1,2
	CLO2: Familiarize with Load Balancing AWS ELB, Nginx, Ipvadm, Ldirectord.	C1 (Know)	1,2
	CLO3: Demonstrate the use of NoSQL, MongoDB and DynamoDB, Revision, MapReduce	C3 (Apply)	3,4,5
	CLO4: Explain Big Data transformation methods.	C2 (Explain)	2,4,5
Syllabus	Introduction To Cloud Computing, Introduction To Cloud Computing (Cont.), AWS Services, EC2 hands, Accessing AWS S3 , Virtualization , Containerization/Dockers, Scalable Web Application in The Cloud, Scalable Web Application in The Cloud (Cont.), Load Balancing AWS ELB, Nginx, Ipvadm, Ldirectord, Web Application Deployment Models, Introduction to Big Data, Introduction to Big Data (Cont.), Introduction to NoSQL, MongoDB and DynamoDB, Revision, MapReduce, Distributed Systems, Consistency and Fault Tolerance in Distributed Systems, Big Data Transformation Methods , Blockchain, Practical Considerations in Cloud Computing, Future of the Cloud Computing and Big Data		
Suggested Instructional/ Reading Material	1. JothyRosenberg and Arthur Mateos;The Cloud at Your Service;Manning Publications. ISBN: 1935182528 2. Paul Zikopoulos and Chris Eaton; Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data; McGraw-Hill. ISBN: 0071790535 3. Kyle Banker, Peter Bakkum, Shaun Verch, Douglas Garrett, and Tim Hawkins; MongoDB in Action, Second Edition. 4. Clinton W. Brownley; Foundations for Analytics with Python from Non-Programmer to Hacker.		

4) Interdisciplinary

Course Title	Calculus and Analytical Geometry		
Course Code	ID-150		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	MS-253: Multivariable Calculus		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know the concepts and applications of calculus and analytical geometry.	C1 (Know)	1
	CLO2: Describe functions, limit, continuity chain rule and related techniques.	C2 (Describe)	1
	CLO3: Identify and solve problems related to differentiation and integration.	C3 (Apply)	1,3
	CLO4: Know the concepts analytical geometry.	C1 (Know)	1
Syllabus	Motivation and applications of the course. Introduction to limits: Limits and Continuity, Techniques of finding limits, Indeterminate forms of limits, Introduction to functions: 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 Normal lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation: Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity. Integral calculus: Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve. Analytical Geometry: Straight lines in R ³ , Equations for planes.		
Suggested Instructional/ Reading Material	- Howard Anton, Irl C. Bivens and Stephen Davis, Calculus, 11th Edition, Wiley, 2016, ISBN-10: 1119228581, ISBN-13: 978-1119228585. - Thomas and Finney, Calculus and Analytic Geometry, 9th Edition, ISBN-13: 978-0201531749, ISBN-10: 0201531747.		

Course Title	Linear Algebra		
Course Code	ID-250		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know the concept and application of linear algebra.	C1 (Know)	1
	CLO2: Describe geometry of vector spaces and optimization.	C2 (Describe)	1
	CLO3: Perform matrix algebra.	C3 (Apply)	1,3
Syllabus	Linear Equations in Linear Algebra: Systems of Linear Equations, Row Reduction and Echelon Forms, Vector Equations, The Matrix Equation $Ax = b$, Solution Sets of Linear Systems, Applications of Linear Systems, Linear Independence, Introduction to Linear Transformations, The Matrix of a Linear Transformation, Linear Models in Business, Science, and Engineering. Matrix Algebra: Matrix Operations, The Inverse of a Matrix, Characterizations of Invertible Matrices, Partitioned Matrices, Matrix Factorizations, Applications to Computer Graphics, Subspaces of R^n, Dimension and Rank. Determinants: Introduction to Determinants, Properties of Determinants, Cramer's Rule, Volume, and Linear Transformations. Vector Spaces: Vector Spaces and Subspaces, Null Spaces, Column Spaces, and Linear Transformations, Linearly Independent Sets; Bases, Coordinate Systems, The Dimension of a Vector Space, Rank, Change of Basis. Eigenvalues and Eigenvectors: Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization, Eigenvectors and Linear Transformations, Complex Eigenvalues, Discrete Dynamical Systems. Orthogonality and Least Squares: Inner Product, Length, and Orthogonality, Orthogonal Sets, Orthogonal Projections, The Gram-Schmidt Process, Least-Squares Problems, Applications to Linear Models, Inner Product Spaces, Applications of Inner Product Spaces. Symmetric Matrices and Quadratic Forms: Diagonalization of Symmetric Matrices, Quadratic Forms, Constrained Optimization, The Singular Value Decomposition, Applications to Image Processing and Statistics. The Geometry of Vector Spaces: Affine Combinations, Affine Independence, Convex Combinations, Hyperplanes. Optimization: Matrix Games, Linear Programming—Geometric Method, Linear Programming—Simplex Method, Duality.		
Suggested Instructional/ Reading Material	1. David C. Lay, Steven R. Lay, Judi J. McDonald, Linear Algebra and Its Applications, 5th Edition, Pearson, 2015, ISBN-13: 978-0321982384, ISBN-10: 032198238X. 2. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016, ISBN-13: 978-0980232776, ISBN-10: 0980232775. 3. Howard Anton, Elementary Linear Algebra, 11th Edition, Wiley, 2013, ISBN-13: 978-0470458211, ISBN-10: 0470458216. 4. Philip N. Klein, Coding the Matrix: Linear Algebra through Applications to Computer Science, 1st Edition, Newtonian Press, 2013, ISBN-13: 978-0615880990, ISBN-10: 0615880991. 5. David Hill, David Zitarelli, Linear Algebra Labs with MATLAB, 3rd Edition, Pearson, 2003, ISBN-13: 978-0131432741, ISBN-10: 0131432745.		

Course Title	Web Technologies		
Course Code	ID-352		
Credit Hours	3 (2,1)		
Category	Interdisciplinary		
Prerequisite	CC-112: Programming Fundamentals		
Co-Requisite	None		
Follow Up	EI-338: Enterprise Systems		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know web application architecture, languages and application.	C1 (Know)	1
	CLO2: Demonstrate understanding of web architecture and protocols. Use modern web development tools and frameworks effectively.	C3 (Apply) (Demonstrate)	2,3,4,5
	CLO3: Design and implement responsive web pages using HTML, CSS, and JavaScript. Work collaboratively to develop and test web applications. Communicate design decisions through documentation and presentations.	C5 (Design) (Collaborate)	4,5,6,7
Syllabus	Introduction: Web Applications, TCP/IP Application Services. Web Servers: Basic Operation, Virtual hosting, Chunked transfers, Caching support, Extensibility. SGML, HTML5, CSS3. XML Languages and Applications: Core XML, XHTML, XHTML MP. Web Services: SOAP, REST, WML, XSL. Operations, Processing HTTP Requests, Processing HTTP Responses, Cookie Coordination, Privacy and P3P, Complex HTTP Interactions, Dynamic Content Delivery. Server Configuration. Server Security. Web Browsers Architecture and Processes: Active Browser Pages: JavaScript, DHTML, AJAX. JSON. Approaches to Web Application Development: Programming in any Scripting language. Search Technologies, Search Engine Optimization. XML Query Language, Semantic Web, Future Web Application Framework. Implementation on compiler of all the concepts/topics discussed in the course which includes, Introduction to Java, Variables, data types, Control Structures, Methods, Classes, Interfaces, Method Overloading and Overriding, Revision of Object oriented programming courses in Java, GUI development, Event Handling, Database Connectivity, Exception Handling, File handling, HTML, CSS, Java Script, Server side Programming in Java, Http Request and Response, Servlets, Servlet Life Cycle, Java Beans, MVC.		
Suggested Instructional/ Reading Material	1. Paul J. Deitel and Harvey Deitel, Java How to Program, 11th Edition, Pearson, 2017, ISBN-10: 0134743350, ISBN-13: 978-0134743356. 2. Marty Hall and Larry Brown, Core Servlets and Java Server Pages, 2nd Edition, Pearson, 2017, ISBN-10: 8131701638, ISBN-13: 978-8131701638.		

Course Title	Mobile Application Development		
Course Code	ID-353		
Credit Hours	3 (2,1)		
Category	Interdisciplinary		
Prerequisite	CC-211: Object Oriented Programming		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain characteristics of mobile application.	C2 (Explain)	1,2
	CLO2: Use Android platform for application development.	C3 (Apply)	1,2,3
	CLO3: Identify potential and applications of data storage technologies.	C4 (Identify)	1,2,3
	CLO4: Use Android Native Development Kit in a mobile application development.	C3 (Apply)	3,4,5
Syllabus	Introduction: Mobile Computing Domain, Comparison of different Mobile Platforms, Revision of Java. Android Platform: Dalvik Virtual Machine, Android Constructs (Activity, Intent, Content Provider, Service, Broadcast Receiver), Activity Lifecycle, Project Structure, Manifest File, Emulators (AVD), Debugging (DDMS), R.java, Inter Activity Communication (Intent), Event Handlers, Layout XML, @ Sign, Layouts, Adapters, Dynamic Lists, Holder Pattern, Menus and dialogs, Menu, Menu Group, Menu Item, Icon Menu, Sub Menu, Context Menu, Sub Menu, Dynamic Menu, Using XML Files for Menus, Services, Intents. Data Storage: Key Value Sets, Files, Intro to SQLite, Web Service Integration, JSON, HTTPClient, Graphics, Widgets & Notifications, Multimedia and telephony API, Android Native Development Kit (NDK).		
Suggested Instructional/ Reading Material	1. Mark L. Murphy, Beginning Android 2, Apress, ISBN 978-1-4302-2629-1 2. Zigurd Mednieks, Laird Dornin, G. Blake Meike, and Masumi Nakamura Programming Android, 2nd Edition, O Reilly Press, ISBN: 978-1-449-31664-8 3. Syed Hashmi, Satya Komatineni, Dave Maclean, Pro Android 2, Apress, ISBN 978-1-4302-2659-8 4. http://developer.android.com/develop/index.htm 5. http://developer.android.com/guide/components/services.html 6. http://developer.android.com/guide/components/intents-filters.html 7. http://developer.android.com/guide/topics/data/data-storage.html 8. http://developer.android.com/guide/topics/graphics/index.html 9. http://developer.android.com/guide/topics/sensors/index.html		

Course Title	Introduction to Economics		
Course Code	ID-171		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand nature and scope of economics.	C2 (Understand)	1
	CLO2: Knowledge of market types, revenue curves, cost curves.	C1 (Knowledge)	1,3,10
	CLO3: Knowledge of central bank, monetary policy, global economics, free trade and protection.	C1 (Knowledge)	1,3,5,10
Syllabus	Nature and scope of economics, three basic economic problems, the economic role of Government, Theory of consumer behaviour, Analysis of market mechanism, Determinants of market forces, Theory of demand and supply, Determination of a value of a commodity, Elasticity of demand and supply, Types of markets, Revenue curves, Cost curves, Software industry analysis, Factor market analysis, Wage determination, problems of labour, capital, interests, entrepreneur & profit, National accounting, national income measurement, GDP, income and growth, National income application-standard of living, Trade development authority, Aggregate demand and supply, Taxation, efficiency, applications to international trade, costs of Taxes & subsidies, Money, finance and the concepts of open economy, Inflation & Unemployment, Types of States, Federal Budget, Role of Government-fiscal policy, Central Bank – Monetary Policy, Global Economics, Free Trade and Protection (WTO).		
Suggested Instructional/ Reading Material	1. Campbell R. McConnell, Stanley L. Brue and Sean Masaki Flynn, Economics, 21 st Edition, McGraw-Hill Education, 2017, ISBN-10: 1259723224, ISBN-13: 978-1259723223.		

Course Title	Introduction to Psychology		
Course Code	ID-276		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Differentiate between Psychologists, Psychoanalyst and Psychiatrist,	C4 (Differentiate)	1,10
	CLO2: Knowledge of important methods in Psychology.	C1 (Knowledge)	1,4,10
	CLO3: Knowledge of composite, cognitive Psychology and social cognition.	C1 (Knowledge)	1,4,10
Syllabus	Introduction to Psychology, Definition of the term Psychology, Psychology and Soul, Relationship of Psychology with Philosophy and deep roots of Psychology in Philosophy, Differentiate between Psychologists, Psychoanalyst and Psychiatrist, Different school of thought in Psychology, An overview of important methods in Psychology, Observational method, Clinical method, Development method, Introspection method, Different branches of Psychology, Child Psychology, Clinical Psychology, Applied Psychology, Individual Psychology, Criminal Psychology, Position of Sigmund Freud as the father of modern Psychology, Conscious / Unconscious / Subconscious, Psychodynamic theories, ID, Ego, Super Ego, Memory, Differentiate between STM and LTM, Forgetting, Causes of Forgetting, Disorders, Sleep and Behavioral disorders, Overview of composite Psychology, Perception, Various processes in Perception, Perception and its various characteristics, Attention, Attention as selective process, Internal and External determinants of attention, Intelligence and Intelligence test, Artificial Intelligence, Computer in any case cannot replace human mind, Cognitive Psychology, Learning, Various process and methods of learning, Nervous System, Definition and part, Types of Nerves, Mental Processes, Brain, Sensation, Types of Sensation, Personality and its Structure, Development, Basis and factors of Development, Social Psychology, Social Cognition, Impression Formation, Dream, Nature Of Dream, Dream as Supernatural Phenomena.		
Suggested Instructional/ Reading Material	1. Samuel E. Wood, Ellen Green Wood, Denise Boyd, The World of Psychology, 7 th Edition, Pearson, 2014, ISBN-13: 978-0205763733, ISBN-10: 0205763731.		

Course Title	Introduction to Marketing		
Course Code	ID-275		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Introduction	This course is designed to provide students with a broad introduction to marketing concepts, to help them understand the factors that influence marketing decisions, and to focus their attention on the vital role of marketing in today's global economy.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Identify some of the basic approaches to formulating a marketing strategy in order to participate effectively when working with marketing policy coordinators.	C1 (Identify)	1, 6, 7
	CLO2: Use an understanding of marketing and the market driven enterprise to differentiate market.	C4 (Differentiate)	1, 3
	CLO3: Identify key stages of the market planning process in order to create marketing plans through development of key sections common to most plans.	C3 (Develop)	1, 3, 4
Course Description	Marketing in Changing World, Core marketing concepts, Creating Customer Value and Satisfaction, Strategic Planning and the Marketing Process, Micro and Macro Marketing Environment, Marketing Research and Information Systems, Consumer Markets and Consumer Buyer Behavior, Business Markets and Business Buyer Behavior, Marketing Segmentation, Targeting, and Positioning for Competitive Advantage Product and Services strategy, New Products Development and Product Life-Cycle Strategies, Pricing Products: Pricing Considerations and Approaches, Pricing Strategies, Distribution Channels and Logistics Management, Retailing and Wholesaling, Integrated Marketing Communication Strategy, Advertising, Sales Promotion and Public Relations, Personal Selling and Sales Management, Direct and Online Marketing, Competitive Strategies: Building Lasting Customer Relationships.		
Suggested Instructional/ Reading Material	7. Kotler P., Armstrong G., Agnihotri P. Y., and Ehsan Ul Haque. 2017. Principles of Marketing: A South Asian Perspective. 13th Ed. Pearson Education, India. 8. Sharp B. 2018. Marketing: Theory, Evidence, Practice. 2nd ed. Oxford University Press.		

Course Title	Introduction to Sociology		
Course Code	ID-273		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Explain role and importance of Sociology.	C2 (Explain)	1
	CLO2: Describe structural functional theory, social conflict theory, Sociobiology, Types of societies.	C2 (Describe)	1,3,4
	CLO3: Know the theory of Change.	C1 (Knowledge)	1,3,4
Syllabus	Introduction to Sociology, Society, basic concepts, Culture, Theories of culture, Structural functional theory, Social conflict theory, Sociobiology, Types of societies, Agrarian Societies, Industrial Societies, Postindustrial Societies, Limits of technology, Karl Marx: Society and Conflict, Max Weber: The Rationalization of Society, Emile Durkheim: Society and Function, Socialization, Agents of Socialization, Groups and Organizations, Formal Organizations, The Evolution of Formal Organizations, Scientific Management, The Changing nature of work, McDonaldization of Society, Crime, Deviance, The Functions of Deviance, Deviance and Inequality, Deviance, Race and Gender, Crime, Politics, Government, Social Movement, Collective Behavior and Social Movements, Social, Change: Traditional, Modern and Postmodern societies Culture and change, Conflict and change, Ideas and change, Demographic change, Dimensions of modernization, Theories of Modernity, Structural Functional Theory, Social Conflict Theory.		
Suggested Instructional/ Reading Material	1. Richard P. Appelbaum, Deborah Carr, Mitchell Duneier and Anthony Giddens , Essentials of Sociology, 6th Edition, W. W. Norton & Company, 2017, ISBN-10: 0393614298, ISBN-13: 978-0393614299.		

Course Title	Financial Accounting		
Course Code	ID-274		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Introduction	This course is designed to introduce students to the knowledge of accounting required to help them understand the process of financial management required to develop modern accounting information systems.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Develop and understand the nature and purpose of financial statements in relationship to decision making.	C2 (Explain)	1, 3, 4
	CLO2: Develop the ability to use the fundamental accounting equation to analyze the effect of business transactions on an organization's accounting records and financial statements.	C4 (Analyze)	3
	CLO3: Develop the ability to use a basic accounting system to create (record, classify, and summarize) the data needed to solve a variety of business problems.	C3 (Operate)	4, 5
	CLO4: Develop the ability to use accounting concepts, principles, and frameworks to analyze and effectively communicate information to a variety of audiences.	C4 (Analyze)	3, 7
	CLO5: Develop the ability to use accounting information to solve a variety of business problems.	C3 (Solve)	3, 4
	CLO6: Develop the ability to interact well with team members.	C5 (Collaborate)	6, 7
Syllabus	Introduction to accounting; Accounting principles; Book keeping; Basics of financial statements; Adjustments to financial statements; The cash book; Bank reconciliation; Control accounts; Statement of cash flows; Financial activities; Property; Plant and equipment (PPE); Accounting errors; Accounting for partnerships; Balance sheet.		
Suggested Instructional/ Reading Material	1. Ghani, M. A. 2020. Principles of Accounting. Pak Imperial Book Depot, Lahore, Pakistan		

Course Title	Organizational Behavior		
Code	ID-373		
Credit Hours	3 (3,0)		
Category	Interdisciplinary		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Understand of Organizational Change and Stress Management, Diversity in Organizations, Organization Culture.	C2 (Understand)	1,3,6,7
	CLO2: Describe Attitudes and Job Satisfaction, Emotions and Moods, Personality and Values, Perception and Individual Decision-making.	C2 (Describe)	1,3,6,7
	CLO3: Know the foundations of Group Behavior.	C1 (Knowledge)	1,3,6,7
Syllabus	Organizational behavior is a field of study that investigates the impact that individuals, groups, and structure have on behavior within organizations, for the purpose of applying such knowledge toward improving an organization's effectiveness. This course focuses on such topics as: Attitudes and Job Satisfaction, Emotions and Moods, Personality and Values, Perception and Individual Decision-making, Motivation Concepts and Applications, Foundations of Group Behavior, Understanding Work Teams, Communication, Leadership, Power and Politics, Organizational Change and Stress Management, Diversity in Organizations, Organization Culture.		
Suggested Instructional/ Reading Material	1. Stephen P. Robbins & Timothy A. Judge, Organizational Behavior, 18th edition, Pearson Education, 2019, ISBN: 978-0134729664 2. Jerald Greenberg, Behavior in Organizations, 10th edition, Pearson Education, 2010, ISBN: 978-0136090199		

5) Math Deficiency

Course Title	Math Deficiency - I		
Course Code	MD-101		
Credit Hours	3* (3,0)		
Category	Math Deficiency		
Prerequisite	None		
Co-Requisite	None		
Follow Up	Math Deficiency-II		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know the concepts and applications of sets, relations, functions, systems of equations, trigonometric functions and matrix algebra	C1 (Know)	1
	CLO2: Describe system of linear equations, matrix algebra, trigonometry and related techniques.	C2 (Describe)	1
	CLO3: Solve problems related to system of linear equations, matrix algebra, and trigonometry.	C3 (Apply)	1,3
	CLO4: Know the general form of Conic, polar coordinate and parametric equations.	C1 (Know)	1
Syllabus	Sets: Definition, various types of set representation and operations. Relation and Function: Graphical transformation of one and two dimensional functions, Properties of functions, composition and inverses of functions, domain and range of the functions, Maximum and minimum values of functions, increasing and decreasing functions, zeros and intercept of functions, piecewise functions, continuity and Discontinuity of functions, Polynomials and rational functions, Polynomial long division and Synthetic division, Solution of rational functions, Absolute valued function, properties of absolute valued functions, Asymptotes (Horizontal, vertical and oblique), Exponential functions and their properties, Logs functions and their properties. Systems of Equations: Systems of Two Equations and Two Unknowns, Systems of Three Equations and Three Unknowns. Matrix Algebra: Addition, subtraction and multiplication. Row Operations and Row Echelon Forms, Augmented Matrices, Determinant of Matrices (2 x 2 and higher order matrices), Cramer's Rule, Inverse Matrices. Series and Sequences. Trigonometry: Angles in Radians and Degrees, Right Triangle Trigonometry, Law of Cosines & Sines, Area of Triangle, Graphs of Other Trigonometric Functions , Graphs of Inverse Trigonometric Functions, Basic Trigonometric Identities (Pythagorean, Sum and Difference, Double, Half, and Power Reducing), Trigonometric Equations. General Form of a Conic: Parabolas, Circles, Ellipses, Hyperbolas, Degenerate Conics. Polar and Parametric Equations: Polar and Rectangular Coordinates.		
Suggested Instructional/ Reading Material	1. Textbook of Algebra and Trigonometry Class XI is published by Punjab Textbook Board (PTB) Lahore, Pakistan. 2. Calculus and Analytic Geometry, MATHEMATICS 12 (Mathematics FSc Part 2 or HSSC-II), Punjab Text Book Board Lahore, Pakistan 3. Gilbert, S. S., B. C. Andy and B. Andrew, B. 2005. Linear Algebra and Its Applications. 4th Ed. Thomson Brooks/Cole, Belmont, CA, USA.		

Course Title	Math Deficiency - II		
Course Code	MD-102		
Credit Hours	3* (3,0)		
Category	Math Deficiency		
Prerequisite	None		
Co-Requisite	None		
Follow Up	Calculus and analytic Geometry		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	BT	PLO
	CLO1: Know the concepts and applications of complex number, sequences, series, permutations and combinations, integration and differentiation	C1 (Know)	1
	CLO2: Describe functions, limit, continuity chain rule and related techniques.	C2 (Describe)	1
	CLO3: Identify and solve problems related to differentiation and integration.	C3 (Apply)	1,3
Syllabus	Complex Numbers: Complex Numbers, Arithmetic with Complex Numbers (Add, subtract, multiply and divide complex numbers), Trigonometric Polar Form of Complex Numbers, De Moivre's Theorem and nth Roots, Recursion. Sequences and Series: Sigma Notation, Arithmetic Series, Geometric Series (Sum infinite and finite geometric series and categorize geometric series). Counting with Permutations and Combinations. Basic Probability. Binomial Theorem. Limit: Notation, Graphs to Find Limits, Tables to Find Limits, Substitution to Find Limits, Rationalization to Find Limits, One Sided Limits and Continuity. Rate of Change: Instantaneous Rate of Change, Tangent Lines and Rates of Change. Derivatives: The Derivative Function, Introduction to Techniques of Differentiation, The Product and Quotient Rules, Derivatives of Trigonometric Functions, The Chain Rule, Derivatives of Logarithmic Functions, Derivatives of Exponential and Inverse Trigonometric Functions. Increase, Decrease, and Concavity, Relative Extrema, Absolute Maxima and Minima. Integrals: An Overview of the Area Problem, Area Under a Curve, The Indefinite Integral, Integration by Substitution, The Definition of Area as a Limit; Sigma Notation, The Definite Integral.		
Suggested Instructional/ Reading Material	1. Textbook of Algebra and Trigonometry Class XI is published by Punjab Textbook Board (PTB) Lahore, Pakistan. 2. Calculus and Analytic Geometry, MATHEMATICS 12 (Mathematics FSc Part 2 or HSSC-II), Punjab Text Book Board Lahore, Pakistan 3. Mark J. Christensen, Computing for Calculus, 1st Edition, Academic Press, (1st January 1981), 240 pages, ISBN: 9781483271088. 4. Lay, L. D. 2015. Probability and Statistics for Engineering and the Sciences, 9th Ed. Cengage Learning, Boston, MA, USA. 5. Howard, Anton, Irl Bivens, Stephen Davis, Calculus, 11th Ed, 2011, John Wiley & Sons, Inc. (1318 Pages)		