ITEM NO. 1

To recommend Curriculum, Course Syllabi, and Model Study Plan for BS Computer Science in the light of the Undergraduate Policy 2023 by Higher Education Commission (HEC) of Pakistan at University of the Punjab, Lahore, Punjab University Gujranwala campus, Punjab University Jhelum campus, Punjab University Pothohar campus, and the affiliated colleges.

BS Computer Science Curriculum Model

Sr.	Category/Area	Credit Hours	Courses	Remarks
1.	Math Deficiency (MD)	*6 (non-credited)	2	Two non-credited math deficiency courses to be offered to the students having pre-medical background during their Intermediate
2.	Computing Core (CC)	46	19	Common to all BS Computing programs
3.	Computer Science Core (DC)	18	6	Domain core courses for BS Computer Science
4.	Computer Science Elective (EC)	21	7	These courses are elective and would be very useful to provide in depth special knowledge under Computer Science
5.	Mathematics & Supporting Courses (MS)	12	4	Common to all computing degree programs
6.	Elective Supporting Courses (UE)	3	1	Common to all computing degree programs
7.	General Education Requirement (GE)	30	12	Common to all computing degree programs
8.	Quran Translation (QT)	4	8	
Total		134	59	

Nomenclature of Course Categories and Course Codes

N	Code	Description	Courses	Cr. Hrs.	
0	MD	Math Deficiency	2	6*	(6,0)*
1	CC	Computing Core	19	46	(30,16)
2	DC	Computer Science Core	6	18	(13,5)
3,4	EC	Computer Science Elective	7	21	(14,7)
5	MS	Mathematics & Supporting Courses	4	12	(12,0)
6,9	GE	General Education Courses	12	30	(28,2)
7	UE	Elective Supporting Courses	1	3	(3,0)
8	HQ	Quran Translation	8	4	(4,0)
		Total	**59**	**134**	**(104,30)**

Course Coding Scheme

Code-YNS

Code = MD, CC, DC, EC, MS, GE, UE, HQ

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

N = Numeric Code = 0, 1, …, 9

S = Serial Number (Resets with Year) = 0, 1, 2, …,9

Lab Codes = Same as related theory course codes with "-L" as suffix

List of Courses

MATHEMATICS DEFICIENCY: 6 (6,0)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	MD-001	Math Deficiency - I		3 (3,0)*
2.	MD-002	Math Deficiency - II		3 (3,0)*

COMPUTING CORE: 46 (30,16)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	CC-112	Programming Fundamentals		3 (3,0)
2.	CC-112-L	Programming Fundamentals Lab		1 (0,1)
3.	CC-211	Object Oriented Programming	CC-112 Programming Fundamentals	3 (3,0)
4.	CC-211-L	Object Oriented Programming Lab	CC-112 Programming Fundamentals	1 (0,1)
5.	CC-215	Database Systems		3 (3,0)
6.	CC-215-L	Database Systems Lab		1 (0,1)
7.	CC-110	Digital Logic Design		2 (2,0)
8.	CC-110-L	Digital Logic Design Lab		1 (0,1)
9.	CC-213	Data Structures	CC-211 Object Oriented Programming	3 (3,0)
10.	CC-213-L	Data Structures Lab	CC-211 Object Oriented Programming	1 (0,1)
11.	CC-312	Information Security		3 (2,1)
12.	CC-310	Artificial Intelligence	CC-213 Data Structures	3 (2,1)
13.	CC-214	Computer Networks		3 (2,1)
14.	CC-212	Software Engineering		3 (3,0)
15.	CC-210	Computer Organization and Assembly Language	CC-110 Digital Logic Design	3 (2,1)
16.	CC-311	Operating Systems		3 (2,1)
17.	CC-313	Analysis of Algorithms	CC-213 Data Structures	3 (3,0)
18.	CC-411	*Final Year Project - I		2 (0,2)
19.	CC-412	*Final Year Project - II	CC-411 Final Year Project - I	4 (0,4)

COMPUTER SCIENCE CORE: 18 (13, 5)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	DC-220	Advanced Database Management Systems	CC-215 Database Systems	3 (2,1)
2.	DC-320	Theory of Automata and Formal Languages		3 (3,0)
3.	DC-321	Human Computer Interaction		3 (2,1)

4.	DC-322	Computer Architecture	CC-210 Computer Organization & Assembly Language	3 (2,1)
5.	DC-328	Parallel & Distributed Computing	CC-311 Operating Systems	3 (2,1)
6.	DC-421	Compiler Construction	DC-320 Theory of Automata and Formal Languages	3 (2,1)

COMPUTER SCIENCE ELECTIVE: 21 (15, 6)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	EC-330	Web Technologies		3(2,1)
2.	EC-333	Mobile Application Development	CC-211 Object Oriented Programming	3(2,1)
3.	EC-324	Software Construction & Development		3(2,1)
4.	EC-335	Machine Learning		3(2,1)
5.	EC-334	Game Design and Development		3(2,1)
6.	EC-345	Computer Vision		3(2,1)
7.	EC-425	Software Quality Engineering	CC-212 Software Engineering	3(2,1)

MATHEMATICS & SUPPORTING: 12 (12, 0)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	MS-253	Multivariable Calculus	GE-162 Calculus & Analytical Geometry	3 (3,0)
2.	MS-252	Linear Algebra		3 (3,0)
3.	MS-251	Probability and Statistics		3 (3,0)
4.	MS-254	Technical and Business Writing		3 (3,0)

GENERAL EDUCATION: 30 (28, 2)

Sr.	Code	Course Title	Sub – Category	Prerequisite	Cr. Hrs.
1.	GE-160	Applications of Information & Communication Technologies			3 (2,1)
2.	GE-190	Functional English			3 (3,0)
3.	GE-191	Expository Writing			3 (3,0)
4.	GE-167	Discrete Structures	Quantitative Reasoning – I		3 (3,0)
5.	GE-162	Calculus & Analytical Geometry	Quantitative Reasoning – II		3 (3,0)
6.	GE-163	Islamic Studies			2 (2,0)
7.	GE-168	Ideology and Constitution of Pakistan			2 (2,0)
8.	GE-192	Introduction to Management	Social Science		2 (2,0)
9.	GE-169	Applied Physics	Natural Science		3 (2,1)
10.	GE-262	Professional Practices	Arts and Humanities		2 (2,0)
11.	GE-363	Civics and Community Management			2 (2,0)
12.	GE-362	Entrepreneurship			2 (2,0)

UNIVERSITY ELECTIVE: 3 (3, 0)
ANY ONE COURSE FROM THE FOLLOWING NON-EXHAUSTIVE LIST OF COURSES

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	UE-272	Introduction to Marketing		3 (3,0)

2. Scheme of Studies / Semester-wise workload

Semester - I						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	MD-001	Math Deficiency – I		MD	3*	(3, 0)*
2.	MS-251	Probability & Statistics		MS	3	(3, 0)
3.	GE-160	Applications of Information & Communication Technologies		GE	3	(2, 1)
4.	GE-169	Applied Physics		GE	3	(2, 1)
5.	GE-167	Discrete Structures		GE	3	(3, 0)
6.	HQ-001	Quran Translation – I.		HQ	0.5	(0.5,0)
7.	GE-190	Functional English		GE	3	(3, 0)
				Credit Hours (Semester – I)	**15.5**	**(13.5, 2)**

Semester – II						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-112	Programming Fundamentals		CC	3	(3, 0)
2.	CC-112-L	Programming Fundamentals Lab		CC	1	(0, 1)
3.	CC-110	Digital Logic Design		CC	2	(2, 0)
4.	CC-110-L	Digital Logic Design Lab		CC	1	(0, 1)
5.	MS-252	Linear Algebra		MS	3	(3, 0)
6.	GE-191	Expository Writing		GE	3	(3, 0)
7.	GE-163	Islamic Studies		GE	2	(2, 0)
8.	HQ-002	Quran Translation – II		HQ	0.5	(0.5,0)
9.	MD-002	Math Deficiency – II		MD	3*	(3, 0)*
				Credit Hours (Semester – II)	**15.5**	**(13.5, 2)**

Semester – III						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-211	Object Oriented Programming	CC-112 Programming Fundamentals	CC	3	(3, 0)
2.	CC-211-L	Object Oriented Programming Lab	CC-112 Programming Fundamentals	CC	1	(0, 1)
3.	CC-215	Database Systems		CC	3	(3, 0)
4.	CC-215-L	Database Systems Lab		CC	1	(0, 1)
5.	CC-210	Computer Organization & Assembly Language	CC-110 Digital Logic Design	CC	3	(2,1)
6.	GE-162	Calculus & Analytical Geometry		GE	3	(3,0)
7.	GE-192	Introduction to Management		GE	2	(2, 0)
8.	HQ-003	Quran Translation – III		HQ	0.5	(0.5,0)
				Credit Hours (Semester – III)	**16.5**	**(13.5, 3)**

Semester – IV						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-213	Data Structures	CC-211 Object Oriented Programming	CC	3	(3,0)
2.	CC-213-L	Data Structures Lab	CC-211 Object Oriented Programming	CC	1	(0,1)
3.	CC-312	Information Security		CC	3	(2,1)
4.	CC-214	Computer Networks		CC	3	(2, 1)
5.	CC-212	Software Engineering		CC	3	(3,0)
6.	DC-220	Advanced Database Management Systems	CC-215 Database Systems	DC	3	(2, 1)
7.	HQ-004	Quran Translation – IV		HQ	0.5	(0.5,0)
				Credit Hours (Semester – IV)	**16.5**	**(12.5, 4)**

Semester – V						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-313	Analysis of Algorithms	CC-213 Data Structures	CC	3	(3, 0)
2.	CC-310	Artificial Intelligence	CC-313 Data Structures	CC	3	(2, 1)
3.	DC-320	Theory of Automata and Formal Languages		DC	3	(3, 0)
4.	DC-321	Human Computer Interaction		DC	3	(2, 1)
5.	DC-322	Computer Architecture	CC-210 Computer Organization & Assembly Language	DC	3	(2, 1)
6.	EC-330	Web Technologies / Elective		EC	3	(2, 1)
7.	HQ-005	Quran Translation – V		HQ	0.5	(0.5,0)
				Credit Hours (Semester – V)	**18.5**	**(14.5, 4)**

Semester – VI						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-311	Operating System		CC	3	(2, 1)
2.	EC-333	Mobile Application Development / Elective	CC-211 Object Oriented Programming	EC	3	(2, 1)
3.	EC-324	Software Construction & Development / Elective		EC	3	(2, 1)
4.	EC-335	Machine Learning / Elective		EC	3	(2, 1)
5.	EC-334	Game Design and Development / Elective		EC	3	(2,1)
6.	MS-253	Multivariable Calculus	GE-162 Calculus & Analytical Geometry	MS	3	(3, 0)
7.	HQ-006	Quran Translation – VI		HQ	0.5	(0.5,0)
				Credit Hours (Semester – VI)	**18.5**	**(13.5, 5)**

Semester – VII						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-411	Final Year Project – I		CC	2	(0, 2)
2.	DC-328	Parallel & Distributed Computing	CC-311 Operating Systems	DC	3	(2, 1)
3.	EC-345	Computer Vision / Elective		EC	3	(2, 1)
4.	EC-425	Software Quality Engineering / Elective	CC-212 Software Engineering	EC	3	(2, 1)
5.	MS-254	Technical and Business Writing		MS	3	(3, 0)
6.	GE-263	Entrepreneurship		GE	2	(2, 0)
7.	GE-262	Professional Practices		GE	2	(2, 0)
8.	HQ-007	Quran Translation – V!I		HQ	0.5	(0.5,0)
				Credit Hours (Semester – VII)	**18.5**	**(14.5, 5)**

Semester – VIII						
Sr.	**Code**	**Course Title**	**Pre-Requisite/Co-Requisite**	**Domain**	**Cr. Hrs.**	
1.	CC-412	Final Year Project – II	CC-411 Final Year Project - I	CC	4	(0, 4)
2.	DC-421	Compiler Construction	DC-320 Theory of Automata and Formal Languages	DC	3	(2, 1)
3.	UE-272	Introduction to Marketing		UE	3	(3, 0)
4.	GE-168	Ideology and Constitution of Pakistan		GE	2	(2, 0)
5.	GE-363	Civics and Community Engagement		GE	2	(2, 0)
6.	HQ-008	Quran Translation – VIII		HQ	0.5	(0.5,0)
				Credit Hours (Semester – VIII)	**14.5**	**(9.5,5)**
				Total Credit Hours	**134**	**(104, 30)**

Program Learning Outcomes (PLOs)[1]

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.

[1] derived from Graduate Attributes define by Seoul Accord www.seoulaccord.org

Using Bloom's Taxonomy for Program Learning Outcomes (PLOs)

Bloom's Taxonomy is a classification of the different outcomes and skills (PLOs). These 6 levels, shown in the table below, that can be used to structure the learning outcomes, lessons, and assessments of a course. Each level of the Bloom's taxonomy maps to one or more PLOs.

Code	Level	Description	Key Words
C1	**Remembering**	Can the students recall or remember the information?	know, describe, identify, label, list, match, memorize, recall
C2	**Understand**	Can the students explain ideas or concepts?	classify, describe, cite, discuss, generalize, illustrate, restate (in own words), summarize
C3	**Applying**	Can the students use the information in a new way?	assess, choose, solve, demonstrate, dramatize, establish, extend, illustrate,
C4	**Analyzing**	Can the students distinguish between different parts?	analyze, appraise, categorize, compare, identify, contrast, criticize, differentiate, recognize
C5	**Creating**	Can the students create new product or point of view?	adapt, incorporate, individualize, integrate, intervene, invent, model, modify, communicate, construct, create, design, develop, formulate, generate, reconstruct, reinforce,
C6	**Evaluating**	Can the students justify a stand or decision?	appraise, argue, choose, compare, conclude, contrast, criticize, interpret, judge, justify, predict, rate

MATHEMATICS DEFICIENCY: 6 (6,0)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	MD-001	Math Deficiency - I		3 (3,0)*
2.	MD-002	Math Deficiency - II		3 (3,0)*

Course Title	**Math Deficiency – I**		
Course Code	**MD-001**		
Credit Hours	3*		
Category	Mathematics 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, trigonometry.	C3 (Apply)	1,3
	CLO4: Know the general form of Conic, polar coordinate and parametric equations.	C1 (Know)	1
Course Description	**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.		
Text Book(s)	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		
Reference Material	1. 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-002**		
Credit Hours	3*		
Category	Mathematics & Supporting (Deficiency Course)		
Prerequisite	None		
Co-Requisite	None		
Follow Up	GE-162 Calculus & 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
Course Description	**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.		
Text Book(s)	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		
Reference Material	1. Mark J. Christensen, Computing for Calculus, 1st Edition, Academic Press, (1st January 1981), 240 pages, ISBN: 9781483271088. 2. Lay, L. D. 2015. Probability and Statistics for Engineering and the Sciences, 9th Ed. Cengage Learning, Boston, MA, USA. 3. Howard, Anton, Irl Bivens, Stephen Davis, Calculus, 11th Ed, 2011, John Wiley & Sons, Inc. (1318 Pages)		

COMPUTING CORE: 46 (30,16)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	CC-112	Programming Fundamentals		3 (3,0)
2.	CC-112-L	Programming Fundamentals Lab		1 (0,1)
3.	CC-211	Object Oriented Programming	CC-112 Programming Fundamentals	3 (3,0)
4.	CC-211-L	Object Oriented Programming Lab	CC-112 Programming Fundamentals	1 (0,1)
5.	CC-215	Database Systems		3 (3,0)
6.	CC-215-L	Database Systems Lab		1 (0,1)
7.	CC-110	Digital Logic Design		2 (2,0)
8.	CC-110	Digital Logic Design Lab		1 (0,1)
9.	CC-213	Data Structures	CC-211 Object Oriented Programming	3 (3,0)
10.	CC-213-L	Data Structures Lab	CC-211 Object Oriented Programming	1 (0,1)
11.	CC-312	Information Security		3 (2,1)
12.	CC-310	Artificial Intelligence	CC-313 Data Structures	3 (2,1)
13.	CC-214	Computer Networks		3 (2,1)
14.	CC-212	Software Engineering		3 (3,0)
15.	CC-210	Computer Organization & Assembly Language	CC-110 Digital Logic Design	3 (2,1)
16.	CC-311	Operating Systems		3 (2,1)
17.	CC-313	Analysis of Algorithms	CC-213 Data Structures	3 (3,0)
18.	CC-411	*Final Year Project - I		2 (0,2)
19.	CC-412	*Final Year Project - II	CC-411 Final Year Project - I	4 (0,4)

*Don’t have a course outline. A final year project report will be submitted by students.

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		
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: Understand basic problem-solving steps and logic constructs.	C2 (Understand)	1,2
	CLO2: Apply basic programing concepts.	C3 (Apply)	3,4
	CLO3: Design and implement algorithms to solve real world problems.	C3 (Solve)	3,4
Course Description	**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.		
Text Book(s)	Paul Deitel, Harvey Deitel, C How To Program, 9th Edition, Pearson, 2022.		
Reference Material	1. Tony Gaddis, Starting out with Programming Logic and Design, 5th Edition, Pearson, 2018. 2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie 3. Object Oriented Programming in C++ by Robert Lafore 1. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Title	**Programming Fundamentals Lab**		
Code	**CC-112-L**		
Credit Hours	1 (0,3)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-211 Object Oriented Programming		
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 lab, the students will be able to:	**BT**	**PLO**
	CLO1: Understand basic problem-solving steps and logic constructs.	C2 (Understand)	1,2
	CLO2: Apply basic programing concepts.	C3 (Apply)	3,4
	CLO3: Design and implement algorithms to solve real world problems.	C3 (Solve)	3,4,5
Course Description	**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.		
Text Book(s)	A. Paul Deitel, Harvey Deitel, C How To Program, 9th Edition, Pearson, 2022.		
Reference Material	1. Tony Gaddis, Starting out with Programming Logic and Design, 5th Edition, Pearson, 2018. 2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie 3. Object Oriented Programming in C++ by Robert Lafore 4. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

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-310 Artificial Intelligence, DC-328 Parallel & Distributed Computing, EC-333 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 principles of object-oriented paradigm.	C2 (Understand)	1
	CLO2: Identify the objects & their relationships to build object-oriented solution	C4 (Identify)	2,3,4
	CLO3: Model a solution for a given problem using object-oriented principles	C3 (Apply)	4
	CLO4: Examine an object-oriented solution	C4 (Examine)	4
Course Description	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.		
Text Book(s)	A. P. Deitel, H. Deitel, C++ How To Program, 10th Edition, Pearson.		
Reference Material	1. Robert Lafore, Object Oriented Programming in C++, 3rd Edition. 2. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, Pearson, 2018. 3. 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 (0,3)		
Category	Computing Core		
Prerequisite	CC-112 Programming Fundamentals		
Co-Requisite	None		
Follow-up	CC-213 Data Structures, CC-310 Artificial Intelligence, DC-328 Parallel & Distributed Computing, EC-333 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 principles of object-oriented paradigm.	C2 (Understand)	1
	CLO2: Identify the objects & their relationships to build object-oriented solution	C4 (Identify)	2,3,4
	CLO3: Model a solution for a given problem using object-oriented principles	C3 (Apply)	4
	CLO4: Examine an object-oriented solution	C4 (Examine)	4
Course Description	***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.		
Text Book(s)	A. P. Deitel, H. Deitel, C++ How To Program, 10th Edition, Pearson.		
Reference Material	1. Robert Lafore, Object Oriented Programming in C++, 3rd Edition. 2. Tony Gaddis, Starting Out with C++ from Control Structures to Objects, 9th Edition, Pearson, 2018. 3. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman		

Course Title	**Database Systems**		
Course Code	**CC-215**		
Credit Hours	3 (3,0)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	The course aims to introduce basic database concepts, different data models, data storage and retrieval techniques and database design techniques. The course primarily focuses on relational data model and DBMS concepts		
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 and Database System environment.	C2 (Understand)	1
	CLO2: To develop strong concepts of data modeling techniques	C2 (Understand)	1,2
	ClO3: Understanding of database design phases and techniques for performance improvement	C2 (Understand)	1,2
	CLO4: To understand the concept of transaction management, concurrency control, database recovery, and distributed databases	C2 (Understand)	1,2
	CLO5: To learn SQL and develop expertise in writing SQL queries	C3 (Apply)	3,4,5
	CLO6: To develop the fundamental knowledge of PL/SQL, stored procedures, and database triggers	C3 (Apply)	3,4,5
	CLO7: To be able to design a database system for small business organizations	C5 (Design)	3,4,5,7
Course Description	**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.		
Text Book(s)	1. Carlos Coronel, Steven Morris, Database Systems: Design, Implementation & Management, 13th Edition, Cengage Learning, 2017. ISBN-10: 1337627909.		
Reference Material	1. Jeffrey A. Hoffer, Ramesh Venkataraman, Heikki Topi, Modern Database Management, 12th Edition, Pearson, 2015. ISBN-10: 0133544613. 2. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015. ISBN-10: 1292061189. 3. 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 (0,3)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
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 followed 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 a database system for small business organizations	C5 (Design)	3,4,5,7
Course Description	**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		
Text Book(s)	1. Introduction to Oracle 9i: SQL 2. Michael McLaughlin, Oracle Database 11g PL/SQL Programming, 1st Edition, McGraw-Hill Education, 2008, ISBN: 0071494456.		
Reference Material	1. Jason Price, Oracle Database 11g SQL, McGraw Hill. ISBN: 0071498508.		

Course Title	**Digital Logic Design**		
Course Code	**CC-110**		
Credit Hours	2 (2, 0)		
Category	Computing core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-210 Computer Organization & Assembly Language		
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	C2 (Understand)	1
	CLO2: Understand the working of the fundamental digital circuits used in digital systems and computers.	C2 (Understand)	1,2
	CLO3: Designing a digital circuit for implementing a given scenario.	C3 (Apply)	3,4
Course Description	**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. Familiarization with Digital Electronic Trainer, Logic gates operations, Half Adder Operation, Full Adder Operation, Half Subtractor Operation, Full Adder Operation, 7-Segment Display Operation, Decoder Operation, BCD To 7-Segment Display, Multiplexer Operation, Using Multiplexer and Demultiplexer / Decoder, Multiplexing 7-Segment Displays, Comparator Operations, D Latch and Flip-Flop Operation, Latching BCD Data for Displaying On 7- Segment Display, JK Flip-Flop Operation, Random Access Memories		
Text Book(s)	M. Morris Mano, Digital Logic and Computer Design, 1st Edition, Pearson, 1979, ISBN: 0132145103.		
Reference Material	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, 3)		
Category	Computing core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	CC-210 Computer Organization & Assembly Language		
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: Designing a digital circuit for implementing a given scenario.	C3 (Apply)	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		

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 Analysis of Algorithms, CC-311 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 course, the students will be able to:	**BT**	**PLO**
	CLO1: Implement various data structures and their algorithms and apply them in implementing simple applications	C3 (Apply)	1,2
	CLO2: Analyze simple algorithms and determine their complexities.	C4 (Analyze)	3
	CLO3: Apply the knowledge of data structure to other application domains	C3 (Apply)	3,4
	CLO4: Design new data structures and algorithms to solve problems	C6 (Design)	4,5
Course Description	**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.		
Text Book(s)	A. Ellis Horowitz, Sartaj Sahni, and D. Mehta, "Fundamentals of Data Structures in C++", 2nd Ed., Computer Science Press		
Reference Material	1. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Ed., Cengage Learning 2. Mark Allen Weiss, "Data Structure and Algorithms in C++", 2nd Ed., Pearson Education 3. D. Malhotra and N. Malhotra. Data Structures and Program Design Using C++. 4. Tenenbaum, M. Augenstein, and Y. Lang Sam, "Data Structures using C and C++" 2nd Ed., Prentice Hall		

Title	**Data Structures Lab**		
Code	**CC-213-L**		
Credit Hours	1 (0,3)		
Category	Computing Core		
Prerequisite	CC-211 Object Oriented Programming		
Co-Requisite	None		
Follow-up	CC-313 Analysis of Algorithms, DI-325 Cyber Security, CC-311 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 various data structures and their algorithms and apply them in implementing simple applications	C3 (Apply)	1,2
	CLO2: Analyze simple algorithms and determine their complexities.	C4 (Analyze)	3
	CLO3: Apply the knowledge of data structure to other application domains	C3 (Apply)	3,4
	CLO4: Design new data structures and algorithms to solve problems	C6 (Design)	4,5
Course Description	***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.		
Text Book(s)	A. Ellis Horowitz, Sartaj Sahni, and D. Mehta, "Fundamentals of Data Structures in C++", 2nd Ed., Computer Science Press		
Reference Material	1. Adam B. Drozdek, Data Structure and Algorithm in C++, 4th Ed., Cengage Learning 2. Mark Allen Weiss, "Data Structure and Algorithms in C++", 2nd Ed., Pearson Education 3. D. Malhotra and N. Malhotra. Data Structures and Program Design Using C++. 4. Tenenbaum, M. Augenstein, and Y. Lang Sam, "Data Structures using C and C++" 2nd Ed., Prentice Hall		

Course Title	**Information Security**		
Course Code	**CC-312**		
Credit Hours	3 (2,1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	This course provides a broad overview of the threats to the security of information systems, the responsibilities and basic tools for information security, and the levels of training and expertise needed in organizations to reach and maintain a state of acceptable security. It covers concepts and applications of system and data security. Areas of particular focus include secure network design, implementation and transition issues, and techniques for responding to security breaches.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Explain key concepts of information security such as design principles, cryptography, risk management, and ethics.	C2 (Explain)	1,2
	CLO2: Discuss legal, ethical, and professional issues in information security.	A2 (Discuss)	1,2
	CLO3: Apply various security and risk management tools for achieving information security and privacy.	C3 (Apply)	3,4,5
	CLO4: Identify appropriate techniques to tackle and solve problems in the discipline of information security.	C4 (Identify)	3,4,5
Course Description	Information security foundations, security design principles; security mechanisms, symmetric and asymmetric cryptography, encryption, hash functions, digital signatures, key management, authentication and access control; software security, vulnerabilities and protections, malware, database security; network security, firewalls, intrusion detection; security policies, policy formation and enforcement, risk assessment, cybercrime, law and ethics in information security, privacy and anonymity of data.		
Text Book(s)	1. M. Whitman and H. Mattord, Principles of Information Security, 6th edition.		
Reference Material	1. William Stallings, Computer Security: Principles and Practice, 3rd edition. 2. Dieter Gollmann, Computer Security, 3rd edition. 3. William Easttom, Computer Security Fundamentals, 3rd edition.		

Course Title	**Artificial Intelligence**		
Course Code	**CC-310**		
Credit Hours	3 (2,1)		
Category	Computing core		
Prerequisite	CC-213 Data Structures		
Co-Requisite	None		
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: Understand the fundamental constructs of Python programming language.	C2 (Understand)	1,2
	CLO2: Understand key concepts in the field of artificial intelligence	C2 (Understand)	1,2
	CLO3: Implement artificial intelligence techniques and case studies	C3 (Apply)	3,4,5
Course Description	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. Introduction to Python programming, 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.		
Text Book(s)	1. Stuart Russell and Peter Norvig, Artificial Intelligence. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2010.		
Reference Material	1. Luger, G.F. and Stubblefield, W.A., 2009. AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley. 2. George F. Luger, Artificial Intelligence - Structures and Strategies for Complex Problem Solving, 6th Edition, Pearson, 2008, ISBN-13: 978-0321545893. 3. Hart, P.E., Stork, D.G. and Duda, R.O., Pattern classification. John Willey & Sons, 2001. 4. Ivan Bratko, Prolog: Programming for Artificial Intelligence, 4th Edition, Pearson, 2011, ISBN-13: 978-0321417466. 5. P. Winston, Artificial Intelligence, 3rd Edition, Pearson, 1992, ISBN-13: 978-0201533774.		

Course Title	**Computer Networks**		
Course Code	**CC-214**		
Credit Hours	3 (2,1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Learning Outcomes (CLOs)	At the end of the lab, the students will be able to:	**BT**	**PLO**
	CLO1: Describe the key terminologies and technologies of computer networks	C2 (Describe)	1
	CLO2: Explain the services and functions provided by each layer in the Internet protocol stack	C2 (Explain)	1
	CLO3: Identify various internetworking devices and protocols and their functions in a networking	C4 (Identify)	1,2
	CLO4: Analyze working and performance of key technologies, algorithms and protocols	C4 (Analyze)	3
	CLO5: Build Computer Network on various Topologies.	P3 (Build)	4,5
Course Description	**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. The lab contents are divided into two parts. After completion of the first part, the students will be able to understand Computer Networks basics, network types, layered communication models and protocols. The contents have been organized in such a way as to form the base for learning the concepts to be taught in the next part. The assimilation of the networking concepts will enable the students to apply them for solving practical problems. After completion of this part, the students will be familiar with networking, routing, switching, and Setting up of networks from scratch, major protocols involved in communication and their configurations. Students will also be made aware of the state of the art areas in case they would like to pursue this course in future.		
Text Book(s)	1. James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, 6th Edition, Pearson, 2012, ISBN: 0132856204. 2. T. Lammle, CCNA Cisco Certified Network Associate Deluxe Study Guide, 6th Edition, Sybex, 2011, ISBN: 978-0-470-90108-3.		
Reference Material	1. Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, 5th Edition, Prentice Hall, 2010, ISBN: 9332518742. 2. William Stallings, Data and Computer Communications, 10th Edition, Pearson, 2013, ISBN: 0133506487. 3. Behrouz A. Forouzan, Data Communication and Computer Networks, 5th Edition, McGraw-Hill, 2012, ISBN: 0073376221. 4. R. Perlman, Interconnections: Bridges, Routers, Switches, and Internetworking Protocols, 2nd Edition, Addison-Wesley, 1999, ISBN: 0201634481.		

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: Describe various software engineering processes and activates	C1 (Describe)	1
	CLO2: Apply the system modeling techniques to model a medium size software system	C3 (Apply)	1,2
	CLO3: Apply software quality assurance and testing principles to medium size software systems	C3 (Apply)	2,3
	CLO4: Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation, and risk analysis	C2 (Discuss)	1, 2
Course Description	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.		
Text Book(s)	1. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2015, ISBN-13: 978-0133943030.		
Reference Material	1. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson, 2002, ISBN-13: 978-0133056990.		

Course Title	**Computer Organization & Assembly Language**		
Course Code	**CC-210**		
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: Acquire the basic knowledge of computer organization computer architecture and assembly language	C2 (Understand)	1
	CLO2: Understand the concepts of basic computer organization, architecture, and assembly language techniques	C2 (Understand)	2
	CLO3: Solve problems related to computer organization and assembly language	C3 (Apply)	3,4,5
Course Description	**Topics:** Introduction to computer systems, Evolution of Intel Microprocessor, Introduction to Assembly Language, Computer Organization, The Components of a Microcomputer System, Instruction Cycle, Memory Architecture, Memory Representation & Hierarchy, Data, Address, Control Busses, Intel 8086 family of Microprocessors, Organization of Intel 8088/8086 Processor, 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 Assembly Language Syntax, Program data, Variables, Variables, Program Structure, 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, STOSSB/W, SCASB/W, CMPSB/W , File Operations, Reading a File, Writing a File		
Text Book(s)	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.		
Reference Material	1. 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. 2. Kip R. Irvine, Assembly Language for Intel Based Computers, 4th Edition, Prentice Hall, 2002, ISBN: 9780130910134.		

Course Title	**Operating Systems**		
Course Code	**CC-311**		
Credit Hours	3 (2,1)		
Category	Computing Core		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
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 and the core functions of the Operating Systems	C2 (Understand)	1,2
	CLO2: Analyze and evaluate the algorithms of the core functions of Operating Systems and explain major performance issues with regard to the core functions	C6 (Evaluate)	3
	CLO3: Demonstrate knowledge in applying system software and tools available in modern operating systems	C3 (Demonstrate)	3,4
Course Description	**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. **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 System Programming:** Linux System Call Interface, Use of GNU gcc compiler **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().		
Text Book(s)	1. A. Silberschatz, P. B. Galvin, G. Gagne, Operating Systems Concepts, 9th Edition, Wiley, 2012, ISBN: 1118063333.		
Reference Material	1. Andrew S. Tanenbaum, Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2014, ISBN: 013359162X. 2. William Stallings, Operating Systems: Internals and Design Principles, 9th Edition, Pearson, 2017, ISBN: 0134670957.		

Course Title	**Analysis of Algorithms**		
Course 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)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm.	C2 (Explain)	1,2
	CLO2: Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.	C3 (Identify)	1,2
	CLO3: Determine informally the time and space complexity of simple algorithms.	C3 (Determine)	2,3
	CLO4: List and contrast standard complexity classes.	C1 (Know)	1.2
	CLO5: Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms.	C3 (Apply)	3,4
	CLO6: Use of the strategies (brute-force, greedy, divide-and conquer, and dynamic programming) to solve an appropriate problem.	C3 (Apply)	3,4
	CLO7: Solve problems using graph algorithms, including single source and all-pairs shortest paths, and at least one minimum spanning tree algorithm.	C3 (Apply)	3,4
	CLO8: Trace and/or implement a string-matching algorithm.	C3 (Apply)	3,4
Course Description	**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.		
Text Book(s)	1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, 3rd Edition, The MIT Press, 2009, ISBN-10: 0262033844, ISBN-13: 978-0262033848		
Reference Material	1. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos 2. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne		

COMPUTER SCIENCE CORE: 18 (13, 5)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	DC-220	Advanced Database Management Systems	CC-215 Database Systems	3 (2,1)
2.	DC-320	Theory of Automata and Formal Languages		3 (3,0)
3.	DC-321	Human Computer Interaction		3 (2,1)
4.	DC-322	Computer Architecture	CC-210 Computer Organization & Assembly Language	3 (2,1)
5.	DC-328	Parallel & Distributed Computing	CC-311 Operating Systems	3 (2,1)
6.	DC-421	Compiler Construction	DC-320 Theory of Automata and Formal Languages	3 (2,1)

Course Title	**Advanced Database Management Systems**		
Course Code	**DC-220**		
Credit Hours	3 (2,1)		
Category	Computer Science Core		
Prerequisite	CC-215 Database Systems		
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: Understanding advance data models, technologies and approaches for building distributed database systems.	C2 (Understand)	1, 2
	CLO2: Applying the models and approaches in order to become enabled to select and apply appropriate methods for a particular case	C3 (Apply)	3, 4
	CLO3: To develop a database solution for a given scenario/ challenging problem in the domain of distributed database systems.	C3 (Apply)	3, 4
Course Description	Introduction to advance data models such as object relational, object oriented. File organizations concepts, Transactional processing and Concurrency control techniques, Recovery techniques, Query processing and optimization, Database Programming (PL/SQL, T-SQL or similar technology), Integrity and security, Database Administration (Role management, managing database access, views), Physical database design and tuning, Distributed database systems, Emerging research trends in database systems, MONGO DB, NO SQL (or similar technologies)		
Text Book(s)	1. Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition by Thomas Connolly and Carolyn Begg 2. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke 3. Database System Concepts, 6th Edition by Avi Silberschatz, Henry F. Korth and S. Sudarshan. 4. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom		
Reference Material			

Course Title	**Theory of Automata and Formal Languages**		
Course Code	**DC-320**		
Credit Hours	3 (3,0)		
Category	Computer Science 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: Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc.	C2 (Understand)	1, 2
	CLO2: Prove properties of languages, grammars and automata with rigorously formal mathematical methods	C2 (Understand)	1, 2
	CLO3: Design of automata, RE and CFG	C3 (Apply)	3, 4
	CLO4: Transform between equivalent NFAs, DFAs and REs	C3 (Apply)	3, 4
	CLO5: Define Turing machines performing simple tasks	C2 (Understand)	1, 2
	CLO-6 Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.	C3 (Apply)	3, 4
Course Description	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.		
Text Book(s)	1. Daniel I. A. Cohen, "Introduction to computer theory", 2nd Ed., Wiley India Pvt. Limited, 2007. ISBN 0471137723, 9780471137726		
Reference Material	1. Peter Linz, "An Introduction to Formal Languages and Automata", 5th Ed., Jones & Bartlett Publishers, 2011. ISBN: 144961552X, 9781449615529		

Course Title	**Human Computer Interaction**		
Course Code	**DC-321**		
Credit Hours	3 (2,1)		
Category	Computer Science 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: HCI Interaction Paradigms.	C2 (Understand)	1, 2
	CLO2: Explain HCI design rules and evaluation techniques.	C2 (Explain)	1, 2
	CLO3: Understand cognitive models.	C2 (Understand)	1, 2
	CLO4: Understand computer mediated communication, ubiquitous computing, and related tools & technologies	C2 (Understand)	2,3,4,5
Course Description	**Topics**: **Interaction Paradigms:** Batch Processing, Time sharing, Networking, Graphical Displays, Microprocessor, WWW, Ubiquitous Computing**. Human:** Fitt's Law, Human Information Processor, Emotions, Psychology and Design of Interactive Systems, Accessibility. **Computers:** capabilities and limitations of Computer Systems, Color Models, New Interactive Systems: Speech, touch, gestures, handwriting recognition. **Interactions:** Models of Interaction, Frameworks, Interaction Styles, User Experience, Interaction Design**. Usability:** HCI in software Process, Learnability, Flexibility, Robustness. **Design Rules:** Principles, Standard (ISO9241), Guidelines, Heuristics (Neilson, Norman, Shneiderman), HCI Patterns (Mobile & Web Application UI). **Implementation Support:** jQuery, User Interface Management System and architectural Patterns. **Evaluation Techniques:** expert analysis (Heuristic Evaluation), Evaluation through user participation: Empirical methods and experiment design, statistical measures, Observational Techniques. **User Support:** Tutorial help, documentation, Wizards, adaptive help. **Cognitive Models:** KLM-GOMS **Task Analysis:** Hierarchical Task Analysis, Knowledge based Analysis, Entity Relationship based Techniques. **Dialog Design:** Diagrammatic Notations: State Transition Networks, Petri Nets, state charts, flow charts. Overview of Textual Notation: Grammars, Production Rules. **Computer Mediated Communication:** groupware, computer mediated communication, Meeting and decision support systems, argumentation Tools, shared application and Artefacts. Issues of Groupware implementation. **Ubiquitous Computing:** Introduction, information and data visualization overview.		
Text Book(s)	1. Alan Dix, Janet Finlay Gregory D Abowd, and Russel Beale, "Human Computer Interaction", 3rd Ed. Pearson Prentice Hall, 2004, ISBN-13: 978-0130461094. 2. Julie A Jacko and Andrew Sears, "The Human Computer Interaction Handbook,", 2nd Ed., CRC, 2007, ISBN 0-8058-5870-9.		
Reference Material	1. Ben Shneiderman, "Designing the User Interface: Strategies for Effective Human-Computer Interaction", 6th Ed., Addison Wesley, 2016, ISBN -13: 978-0134380384: 2. William Albert and Thomas Tullis, "Measuring the User Experience", Morgan Kaufmann, 2013, Paperback ISBN: 9780124157811 3. Helen Sharp, Jenny Preece and Yvonne Rogers, "Interaction Design: Beyond Human-Computer Interaction", Wiley, 2002, ISBN-13: 978-0470665763 4. http://www.ui-patterns.com 5. http://www.androidpatterns.com 6. http://www.usability.gov		

Course Title	**Computer Architecture**		
Course Code	**DC-322**		
Credit Hours	3 (2,1)		
Category	Computer Science Core		
Prerequisite	CC-210 Computer Organization & Assembly language		
Co-Requisite	None		
Follow-up	None		
Course Introduction	There are many computer applications which have diverse requirements as high performance, low power and small size in memory. These requirements have resulted in different hardware like multicore/many-core systems, GPUs, FPGAs and embedded systems. Building on digital logic design, this course goes through the techniques that help in designing a modern microprocessor.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Explain that the hardware components of the CPU, I/O units, Memory units and Instruction Set are designed in a single computer system to execute the program.	C2 (Explain)	3
	CLO2: Explain that the CPU can be implemented as either hardwired or microprogrammed.	C2 (Explain)	3
	CLO3: Understand the various I/O processes according to the characteristics of each I/O unit.	C2 (Understand)	4,5
	CLO4: Understamd engineering techniques (cache memory, virtual memory) that can be applied to system memory.	C2 (Understand)	4,5
Course Description	**Introduction** to basic hardware components and devices, **Register Transfer and Micro-operations**, RTL Register Transfer Language, Register, bus and memory transfers, Arithmetic, Logic and Shift micro-operations, **:** Computer Instructions and instruction codes , **Hardware design:** Computer registers, Design of arithmetic logic unit, Design of hardwired control unit, Timing and control, Instruction cycle, **Instruction types:** Register to register transfer instructions, Memory reference instructions, Input-output and interrupt, Complete design of basic computer, **Microprogrammed Control,** Control memory, Address sequencing, Design of microprogrammed control unit, **Introduction to MIPS ISA**, **The Processor:** Introduction to processor design, Logic Design Conventions, Building a Datapath, A Simple Implementation Scheme, An Overview of Pipelining, Pipelined Datapath and Control, Data Hazards: Forwarding versus Stalling, Control Hazards, **Large and Fast: Exploiting Memory Hierarchy:** Introduction, Memory Technologies, The Basics of Caches, Measuring and Improving Cache Performance, Dependable Memory Hierarchy		
Text Book(s)	1. Computer System Architecture, Third Edition by M. Morris Mano. 2. Computer Organization and design fourth edition by Hennessy and Patterson		
Reference Material			

Course Title	**Parallel & Distributed Computing**		
Course Code	**DC-328**		
Credit Hours	3 (2,1)		
Category	Computer Science Core		
Prerequisite	CC-311 Operating Systems		
Co-Requisite	None		
Follow-up	None		
Course Introduction	The demand of huge computation and storage resources has been increasing exponentially. The course provides the methods for dealing with the emerging challenges of enhancing the power of the computational resources. This course will introduce topics related to parallel and distributed computing and also expose students to the latest tools and technologies.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Learn about parallel and distributed computers.	C1 (Know)	1
	CLO2: Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library.	C3 (Demonstrate)	3.4.5
	CLO3: Analyze complex problems with shared memory programming with openMP.	C4 (Analyze)	3
Course Description	Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD, multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE).		
Text Book(s)	1. Distributed Systems: Principles and Paradigms, A. S. Tanenbaum and M. V. Steen, Prentice Hall, 2nd Edition, 2007		
Reference Material	1. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, KHwang, J Dongarra and GC. C. Fox, Elsevier, 1st Ed.		

Title	**Compiler Construction**		
Code	**DC-421**		
Credit Hours	3 (2, 1)		
Category	Computer Science Core		
Prerequisite	DC-320 Theory of Automata and Formal Languages		
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: Translate and interpret computer language.	C3 (Demonstrate)	
	CLO2: Explain concepts of the basic theory of compilers.	C2 (Explain)	
	CLO3: Evaluate the issues involved in implementing a compiler.	C4 (Analyze)	
	CLO4: Know how compiler works.	C2 (Understand)	
	CLO5: Design and implement parser and compiler for any language.	C3 (Apply)	3, 4
	CLO6: Design specification independent lexical analyzer and syntax analyzer.	C3 (Apply)	
Course Description	The course introduces the students to the operation of a modern compiler that translates code in a programming language into machine code. Special emphasis is placed on the actual construction of a compiler by working on a project that builds a compiler for a language that is a subset of C++. Modern compilers operate in three passes. These are front-end, middle end and back end. Given a program written in a programming language, the front end carries out syntax analysis of input program. The middle end performs code optimization so that the eventual executable program will require less memory and will be efficient at runtime. The back end generates actual assembly language code for the target machine. We will study mechanics of the three stages. However, due to the introductory nature of the course, we will spend majority of the time on syntax analysis and code generation. We will touch upon optimization briefly. In sum, the course provides a practical opportunity to see how concepts and techniques from various areas of Computer Science come together to build a useful tool.		
Text Book(s)	1. Aho, Alfred V. Compilers: principles, techniques and tools (for Anna University), 2/e. Pearson Education India, 2006. 2. Mogensen, Torben Ægidius. Basics of compiler design. Torben Ægidius Mogensen, 2009.		
Reference Material	1. https://doc.lagout.org/programmation/Compiler/Aho%20-%20Compilers%20-% (helping material) 2. http://www.diku.dk/~torbenm/Basics/basics_lulu2.pdf		

COMPUTER SCIENCE ELECTIVE: 21 (14, 7)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	EC-330	Web Technologies		3(2,1)
2.	EC-333	Mobile Application Development	CC-211 Object Oriented Programming	3(2,1)
3.	EC-324	Software Construction & Development		3(2,1)
4.	EC-335	Machine Learning		3(2,1)
5.	EC-334	Game Design and Development		3(2,1)
6.	EC-345	Computer Vision		3(2,1)
7.	EC-425	Software Quality Engineering	CC-212 Software Engineering	3(2,1)

Course Title	**Web Technologies**		
Course Code	**EC-330**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
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 web application architecture and, languages and application.	C1 (Know)	1
	CLO2: Describe various approaches to web application development.	C2 (Describe)	1
	CLO3: Develop web applications.	C3 (Apply)	1,3
Course Description	**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, XHTM 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:** Programing 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.		
Text Book(s)	1. Paul J. Deitel and Harvey Deitel, Java How to Program, 11th Edition, Pearson, 2017, ISBN-10: 0134743350, ISBN-13: 978-0134743356.		
Reference Material	1. 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	**EC-333**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
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 Andriod 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
Course Description	**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).		
Text Book(s)	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		
Reference Material	1. http://developer.android.com/develop/index.htm 2. http://developer.android.com/guide/components/services.html 3. http://developer.android.com/guide/components/intents-filters.html 4. http://developer.android.com/guide/topics/data/data-storage.html 5. http://developer.android.com/guide/topics/graphics/index.html 6. http://developer.android.com/guide/topics/sensors/index.html		

Course Title	**Software Construction & Development**		
Course Code	**EC-324**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
Prerequisite	None		
Co-Requisite	None		
Follow-up	None		
Course Introduction	The software development process includes software engineering processes, process improvement, and life cycle models. Key aspects are code salvaging, configuration management, handling legacy code, and refactoring. Important practices involve exception handling, ensuring robustness, release management, and addressing evolution and maintenance. Personal and peer reviews are essential for quality assurance and fault tolerance.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Understand the role of design and its major activities within the OO software development process, with focus on the Unified process.	C1 (Remember)	1.2.3
	CLO2: Develop Object-oriented design models and refine them to reflect implementation details.	C3 (Apply)	4
	CLO3: Evaluate different architectures for a medium size software.	C4 (Analyze)	3
	CLO4: Implement design model using an object-oriented programming language.	C4 (Analyze)	4.5
Course Description	Software development process, Software engineering process infrastructure, Software engineering process improvement, Systems engineering life cycle models, Process implementation, Levels of process definition, Life cycle model characteristics, Individual and team software process, Lehman's Laws, code salvaging, and configuration management. Martin Fowler's refactoring concepts and their application to small projects. Apply Michael Feathers' "legacy code" concepts. Exception handling, making methods robust by having them check their inputs sent from calling objects. Software configuration management, Release management, Software configuration management processes, Software deployment processes, Distribution and backup, Evolution processes and activities, Basic concepts of evolution and maintenance, Working with legacy systems, Refactoring, Error handling, exception handling, and fault tolerance. Personal reviews (design, code, etc.), Peer reviews (inspections, walkthroughs, etc.).		
Text Book(s)	1. Clean Code: A Handbook of Agile Software Craftsmanship, Robert C. Martin, Prentice Hall, 2008.		
Reference Material	1. The Pragmatic Programmer: From Journeyman to Master, Andrew Hunt and David Thomas, Addison-Wesley Professional, 1999. 2. Working Effectively with Legacy Code, Michael C. Feathers. Pearson Education, Prentice-Hall, 2004. 3. Refactoring: Improving the Design of Existing Code, Martin Fowler, Addison-Wesley Professional. 1999.		

Title	**Machine Learning**		
Code	**EC-335**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
Prerequisite	None		
Co-Requisite	None		
Follow-up	Applications of Machine Learning		
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: Understand the key concepts and principles of machine learning algorithms and their applications in various domains.	C2 (Understand)	1,2
	CLO2: Demonstrate proficiency in implementing and fine-tuning supervised and unsupervised ML models to solve moderately complex problems.	C3 (Demonstrate)	1,2,3
	CLO3: Selection and evaluation of appropriate evaluation metrics to assess the performance and generalization of ML models.	C3 (Differentiate)	1,2,3
	CLO4: Effectively preprocess and transform data	C3 (Apply)	2,3,4
	CLO5: Apply machine learning techniques to analyze and extract insights from large datasets	C3 (Apply)	2,3,4,5
	CLO6: Gain practical experience in designing and conducting experiments, analyzing model results, and iteratively improving model performance	C3 (Apply)	2,3,4,5
Course Description	**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.		
Text Book(s)	1. Introduction to Machine Learning by Ethem Alpaydin		

Reference Material	1. The Hundred-Page Machine Learning Book by Andriy Burkov 2. Hands On Machine Learning with Scikit Learn, Keras and TensorFlow 2e by Aurélien Géron 3. Deep Learning with Python by François Chollet 4. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

Course Title	**Game Design and Development**		
Course Code	EC-334		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
Prerequisite	None		
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.		
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 (Explain)	1,2
	CLO2: Identify the roles and responsibilities within a game development team.	C4 (Identify)	?
	CLO3: Apply programming skills to develop interactive games.	C3 (Apply)	?
	CLO4: Create game assets, including art, music, and animations, using various tools.	C3 (Understand)	?
	CLO5: Implement mathematical and physical concepts in game mechanics.	C5 (Create)	?
	CLO6: Implement basic artificial intelligence in game development.	C3 (Apply)	?
Course Description	**Introduction to Game Development and Design:** This course provides an in-depth exploration of the essential components and processes involved in creating video games. Topics covered include the fundamentals of game design, the principles of game mechanics, and the use of various game development tools. Students will learn about the scope of game development, including its application in education, business, entertainment, and emerging technologies. The course will cover basic game development tools, such as Unity 3D, Spriter, Inkscape, and Magicavoxel, and their effective use in creating game assets. **Game Development Tools:** Effective use of game development environments, including Unity 3D for game creation, Spriter for animations, Inkscape for vector graphics, and Magicavoxel for voxel art. Understanding the integration of these tools for a cohesive game development workflow. **Game Design Process:** The course will delve into the methodologies of game development, including paper prototyping, agile development, and iterative design. Students will learn to create compelling narratives, storyboards, characters, and objects that enhance the gaming experience. **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 that enhance gameplay. **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:** Addressing the challenges of porting games to multiple platforms to ensure broad accessibility and optimal performance. Strategies for adapting game content and functionality across different devices. **Team Collaboration and Project Management:** Structuring game development teams, defining roles, and managing project workflows. Emphasis on team collaboration, effective communication, and iterative development to ensure successful project completion. **Ethical and Legal Considerations:** Understanding intellectual property rights, copyright issues, and ensuring originality in content creation. Emphasis on ethical practices and legal compliance in game development.
Practical Requirements	1. Guided Tutorials and Exercises: Students will engage in tutorials and exercises to gain proficiency in game development tools such as Unity 3D for programming, Spriter for animations, and Inkscape for art creation. Practical tasks will involve creating basic game prototypes, developing animations, and designing game assets. 2. Project-Based Assignments: Students will work on assignments that require them to apply game design principles to create interactive games. Tasks will include developing game mechanics, implementing mathematical and physical concepts, and integrating artificial intelligence. Projects will be submitted for peer and instructor review, allowing for iterative improvements. 3. Team Collaboration: Students will participate in group projects to simulate real-world game development environments. This will involve managing project tasks, coordinating with team members, and using collaborative tools for version control and project management. Practical experience will include using platforms for project tracking, documentation, and team communication. 4. Portfolio Development: As part of the course, students will compile a portfolio showcasing their game development work, including prototypes, final projects, and documentation. This portfolio will be used to evaluate their practical skills and serve as a tool for future job applications or further academic pursuits.
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 8. Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C by Jeremy Gibson Bond - (2022) - ISBN-13: 978-0136877701

Course Title	**Computer Vision**		
Course Code	**EC-345**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
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: Understanding the single view geometry concepts	C2 (understand)	1,2
	CLO2: Understanding the multiple view geometry concepts	C2 (understand)	1,2,3
	CLO3: Apply concepts of CV for solving real world problems	C3 (Apply)	1,2,3
Syllabus	Introduction to Computer Vision (Problems faced, History and Modern Advancements). Image Processing, Image filtering, Image pyramids and Fourier transform, Hough transform. Camera models, Setting up a camera model from parameters, Camera looking at a plane, Relationship of plane and horizon line, Rotation about camera center. Concatenation, Decomposition and Estimation of transformation from point correspondences, Points and planes in 2D/3D, Transformations in 2D/3D, Rotations in 2D/3D. Edge detection, corner detection. Feature descriptors and matching (HoG features, SIFT, SURF). Applications of Computer Vision Traditional Methods: Image Stitching: Making a bigger picture from smaller pictures Single View Geometry: Converting a single image into a 3D model. Applications of CV using Deep Learning: Image Detection (Localization, Historical Techniques, RCNN, FRCNN, YOLO, Retina), Image Segmentation (UNet, SegNet, MaskRCNN), Image Generation (GANN)		
Suggested Instructional/ Reading Material	1. Computer Vision: Algorithms and Applications, by Richard Szeliski. **Reference Book:** 2. Multiple View Geometry in Computer Vision, by Richard Hartley and Andrew Zisserman. 3. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce. 4. Digital Image Processing, by Rafael Gonzalez and Richard Woods.		

Course Title	**Software Quality Engineering**		
Course Code	**EC-425**		
Credit Hours	3 (2,1)		
Category	Computer Science Elective		
Prerequisite	CC-212 Software Engineering		
Co-Requisite	None		
Follow Up	None		
Course Introduction	This course is designed to introduce students to the core principles, methods, and practices of Software Quality Assurance. Through a blend of theory and hands-on exercises, learners will gain a deeper understanding of what it takes to ensure software products meet the required standards of quality before they reach the end-user.		
Course Learning Outcomes (CLOs)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Outline software testing and software quality assurance principles.	C1 (Remember)	1, 2
	CLO2: Prepare test case and test suites for completely testing all aspects of a system under test (SUT)	C3 (Apply)	4, 5
	CLO3: Analyze which of the software testing techniques are relevant for a particular case and know software reliability analysis tools and techniques.	C4 (Analyze)	3
	CLO4: Compile findings of a quality assurance cycle.	C5 (Create)	3
Course Description	Software Quality, Software Quality Attributes, Quality Engineering., Testing: Concepts, Issues, and Techniques, Software testing lifecycle., Testing Scopes., Testing Approaches., Testing Concepts., Test Planning Process, Introduction to testing process, Requirement of software test planning, Testing documentation, Reporting and historical data recording., Software testing techniques, Testing philosophies , Testing strategies, Model based testing, Software testing techniques, Testing using models, Domain and combinatorial testing, Unit and integration testing, Acceptance testing, Test automation, Slicing, Software reliability models and engineering, Introduction, Exponential model., Reliability growth models, Modeling process, Software inspections, Software reviews, Inspection checks and metrics, Quality Models, Models for quality assessment, Product quality metrics, Quality Measurements, In-Process metrics for software testing, In-Process quality management, Effort/outcome models, System testing, Introduction to sub-system testing, From functional to system aspects of testing, System testing, Introduction to system testing, Scenarios development, System testing, Use-cases for testing, Specification-based testing, Open issues on software testing		
Text Book/s	1. Paul Jorgensen, Software Testing, A Craftsman's Approach, 4th Ed. CRC Press, Taylor and Francis Group, 2015		
Reference Material	1. Bernard Homes, Fundamentals of Software Testing, ISTE, Wiley, 2012 2. Software Engineering, "Ian Sommerville, 9th Edition, Addison Wesley, 2011		

MATHEMATICS & SUPPORTING: 12 (12, 0)

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	MS-253	Multivariable Calculus	GE-162 Calculus & Analytical Geometry	3 (3,0)
2.	MS-252	Linear Algebra		3 (3,0)
3.	MS-251	Probability and Statistics		3 (3,0)
4.	MS-254	Technical and Business Writing		3 (3,0)

Course Title	**Multivariable Calculus**		
Course Code	**MS-253**		
Credit Hours	3 (3,0)		
Category	Mathematics & Supporting		
Prerequisite	GE-162 Calculus & Analytical Geometry		
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 concepts and applications of multivariable calculus	C1 (Know)	1
	CLO2: Describe scalar and vector products related techniques.	C2 (Describe)	1
	CLO3: Identify and solve problems related to differentiation and integration.	C3 (Apply)	1,3
	CLO4: Know the concepts of divergence, curl, vector fields and related theorems.	C1 (Know)	1
Course Description	**Topics**: Motivation and applications of the course, Rectangular coordinates in 3-space, spheres, cylindrical surfaces, Vectors, Scalar (dot) products, projections, Vector (cross) products, Parametric Equations of Lines, Planes in 3-space, Quadric surfaces, Spherical and cylindrical coordinates, Introduction to vector-valued functions, Calculus of vector-valued functions, Change of parameter, Arc length, Unit tangent **,** normal, and binormal vectors, Curvature, Functions of two or more variables, Limits, Continuity, Partial derivatives, Differentiability, Local Linearity, Differentials, The Chain rule, Directional derivatives and Gradients, Tangent planes and normal vectors, Maxima and minima of functions of two variables, Lagrange multipliers, Double integral, Double integrals over Nonrectangular Regions, Double integrals in Polar Coordinates, Parametric surfaces, Surface area, Triple integrals, Triple Integrals in Cylindrical and Spherical Coordinates, Divergence and Curl of vector valued functions, Line integrals, Conservative Vector Fields, Green's Theorem, Surface integrals, application of surface integrals(Flux), Divergence Theorem, Stokes' theorem.		
Text Book(s)	Howard Anton, Irl C. Bivens and Stephen Davis, Calculus, 11th Edition, Wiley, 2016, ISBN-10: 1119228581, ISBN-13: 978-1119228585.		

Course Title	**Linear Algebra**		
Course Code	**MS-252**		
Credit Hours	3 (3,0)		
Category	Mathematics & supporting		
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 leaner algebra.	C1 (Know)	1
	CLO2: Describe geometry of vector spaces and optimization.	C2 (Describe)	1
	CLO3: Perform matrix algebra.	C3 (Apply)	1,3
Course Description	**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.		
Text Book(s)	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.		
Reference Material	1. 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. 2. David Hill, David Zitarelli, Linear Algebra Labs with MATLAB, 3rd Edition, Pearson, 2003, ISBN-13: 978-0131432741, ISBN-10: 0131432745.		

Course Title	**Probability and Statistics**		
Course Code	**MS-251**		
Credit Hours	3 (3,0)		
Category	Mathematics & Supporting		
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
Course Description	**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 S2, t-Distribution, F-Quantile and Probability Plots. **Single Sample & One- and Two-Sample Estimation Problems**: Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of P-Values for Decision Making in Testing Hypotheses (Single Sample & One- and Two-Sample Tests). **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.		
Text Book(s)	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.		
Reference Material	1. MIT open courseware: https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/		

Course Title	**Technical and Business Writing**		
Course Code	**MS-254**		
Credit Hours	3 (3,0)		
Category	Mathematics & Supporting		
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: Understanding of technical reporting.	C2 (Understand)	1,6,7,10
	CLO2: Organizing information and generation of solution	C3 (Apply)	1,6,7,10
	CLO3: Writing Proposals and Reports	C3 (Demonstrate)	1,6,7,10
Course Description	Overview of technical reporting, use of library and information gathering, administering questionnaires, reviewing the gathered information; Technical exposition; topical arrangement, exemplification, definition, classification and division, causal analysis, effective exposition, technical narration, description and argumentation, persuasive strategy, Organizing information and generation solution: brainstorming, organizing material, construction of the formal outline, outlining conventions, electronic communication, generation solutions. Polishing style: paragraphs, listening sentence structure, clarity, length and order, pomposity, empty words, pompous vocabulary, document design: document structure, preamble, summaries, abstracts, table of contents, footnotes, glossaries, cross-referencing, plagiarism, citation and bibliography, glossaries, index, appendices, typesetting systems, creating the professional report; elements, mechanical elements and graphical elements. Reports: Proposals, progress reports, Leaflets, brochures, handbooks, magazines articles, research papers, feasibility reports, project reports, technical research reports, manuals and documentation, thesis. Electronic documents, Linear versus hierarchical structure documents, Business Letters; Proposals and Business Plans; Writing Proposals and Reports; Short Reports; Long Formal Reports; Specification Documents; Review of Language; Writing Technical Research Reports; Documentation and Research Citation; Job Application and Resumes.		
Text Book(s)	1. D. O'Hair, J. S. O'Rourke, M.J. O'Hair, Business Communication: A Framework for Success, 1st Edition, Cengage Learning, 2000, ISBN-13: 978-0324073508. 2. Herta A. Murphy, Herbert W. Hildebrandt and Jane P. Thomas, Effective Business Communication, 7th Edition, McGraw Hill India, 2008, ISBN-13: 978-0070187757. 3. Courtland L. Bovee, John V. Thill, Business Communication Today, 12th Edition, Prentice Hall, 2013, ISBN-13: 978-0132971294.		
Reference Material	1. J. M. Penrose, R. W. Rasberry, R. J. Myers, Advance Business Communication, 4th Edition, South-Western Publishers, 2000, ISBN-13: 978-0324037395. 2. Kitty O. Locker, Business and Administrative Communication, 11th Edition, McGraw-Hill Education, 2014, ISBN-13: 978-0073403250.		

GENERAL EDUCATION: 30 (28, 2)

Sr.	Code	Course Title	Sub – Category	Prerequisite	Cr. Hrs.
1.	GE-160	Applications of Information & Communication Technologies			3 (2,1)
2.	GE-190	Functional English			3 (3,0)
3.	GE-191	Expository Writing			3 (3,0)
4.	GE-167	Discrete Structures	Quantitative Reasoning – I		3 (3,0)
5.	GE-162	Calculus & Analytical Geometry	Quantitative Reasoning – II		3 (3,0)
6.	GE-163	Islamic Studies			2 (2,0)
7.	GE-168	Ideology and Constitution of Pakistan			2 (2,0)
8.	GE-192	Introduction to Management	Social Science		2 (2,0)
9.	GE-169	Applied Physics	Natural Science		3 (2,1)
10.	GE-262	Professional Practices	Arts and Humanities		2 (2,0)
11.	GE-363	Civics and Community Management			2 (2,0)
12.	GE-362	Entrepreneurship			2 (2,0)

Course Title	**Applications of Information & Communication Technologies**		
Course Code	**GE-160**		
Credit Hours	3 (2,1)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow Up	None		
Course Introduction	The 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 various software related to ICT.		
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 ethical and legal considerations in use of ICT platforms and tools.	C2 (Understand)	1,2,3
Course Description	**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 (Gamail, 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.

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 through effective use of word choices, grammar and sentence structure.	C4 (Apply)	1,6,7,10
	CL2: Comprehend a variety of literary / non-literary written and spoken texts in English.	C2 (Understand)	1,6,7,10
	CLO3: Effectively express information, ideas and opinions in written and spoken English.	C2 (Explain)	1,6,7,10
	CLO4: Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.	C4 (Identify)	1,6,7,10
Course Description	**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.)		
Practical Requirements	As part of the overall learning requirements, students will also be exposed to relevant simulations, role-plays and real-life scenarios and will be required to apply skills acquired throughout the course in the form of a final project.		
Suggested Instructional / Reading Material	1. "Understanding and Using English Grammar" by Betty Schrampfer 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. 1. "Communication Skills for Business Professionals" by J.P. Verma and Meenakshi Raman.		

Title	**Expository Writing**		
Code	**GE-191**		
Credit Hours	3 (3,0)		
Category	General Education		
Prerequisite	None		
Co-Requisite	None		
Follow-up	MS-254 Technical and Business Writing		
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 essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.	C2 (Understand)	1,6,7,10
	CLO2: Demonstrate mastery of diverse expository types to address different purposes and audiences.	C3 (Apply)	1,6,7,10
	CLO3: Uphold ethical practices to maintain originality in expository writing.	C3 (Demonstrate)	1,6,7,9
Course Description	**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. "Writing Analytically" by David Rosenwasser and Jill Stephen. 4. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup. 5. "The Elements of Style" by William Strunk Jr. and E.B. White. 6. "Good Reasons with Contemporary Arguments" by Lester Faigley and Jack Selzer. 7. "Writing to Learn; How to Write – and Think – Clearly About Any Subject at All" by William Zinsser. 8. "The Norton Field Guide to Writing" by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg. 9. "The Art of Styling Sentences" by Ann Longknife and K.D. Sullivan. 1. "Writing Today" by Richard Johnson-Sheehan and Charles Paine.

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 (Differentiate)	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.		
Text Book(s)	1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 7th Edition, McGraw Higher-Ed, 2011, ISBN: 0073383090.		
Reference Material	1. Susanna S. Epp, Discrete Mathematics with Applications, 4th Edition. 2. Richard Johnson Baugh, Discrete Mathematics, 7th Edition. 3. Kolman, Busby & Ross, Discrete Mathematical Structures, 4th Edition. 4. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition. 5. Winifred Grassman, Logic and Discrete Mathematics: A Computer Science Perspective, 1st Edition.		

Course Title	**Calculus & Analytical Geometry**		
Course Code	**GE-162**		
Credit Hours	3 (3,0)		
Category	General Education		
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
Course Description	Motivation and applications of the course. **Introduction to limits**: Limits and Continuity, Techniques of funding 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 R3, Equations for planes.		
Text Book(s)	1. Howard Anton, Irl C. Bivens and Stephen Davis, Calculus, 11th Edition, Wiley, 2016, ISBN-10: 1119228581, ISBN-13: 978-1119228585.		
Reference Material	1. Thomas and Finney, Calculus and Analytic Geometry, 9th Edition, ISBN-13: 978-0201531749, ISBN-10: 0201531747.		

Title	**Islamic Studies**		
Code	**GE-163**		
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

Course Description	1۔قرآن مجید 1۔ قرآن مجید: معنی و مفہوم، اہمیت و فضیلت، آداب و شرائطِ تلاوت 2۔ وحی کا معنی و مفہوم، وحی کی اقسام 3۔ قرآن مجید کی جمع و تدوین، حفاظت قرآن 2۔حدیثِ نبوی صلی اللہ علیہ وآلہ وسلم 1۔ حدیث کا معنی و مفہوم، اقسام حدیث (قولی۔ فعلی۔ تقریری) 2۔ ضرورت و اہمیتِ حدیث 3۔ مطالعہ حدیث (ترجمہ 6+تشریح 4=10 نمبر) 1۔عَنْ عُمَرَ بْنِ الْخَطَّابِ رضی اللہ عنہ قَالَ سَمِعْتُ رَسُوْلَ اللّٰہِ ﷺ یَقُوْلُ :اِنَّمَا الْاَعْمَالُ بِالنِّیَّاتِ ،وَاِنَّمَا لِامْرِیءٍ مَّا نَوٰی ، فَمَنْ کَانَتْ ھِجْرَتُہٗ اِلٰی اللّٰہِ وَرَسُوْلِہٖ فَھِجْرَتُہٗ اِلَی اللّٰہِ وَرَسُوْلِہٖ ،وَمَنْ کَانَتْ ھِجْرَتُہٗ اِلٰی دُنْیَا یُصِیْبُھَا ،اَوِ امْرَاَۃٍ یَّنْکِحُھَا فَھِجْرَتُہٗ اِلٰی مَا ھَاجَرَ اِلَیْہِ (صحیح بخاری:1) 2۔عَنْ عُثْمَانَ بْنِ عَفَّانَ رضی اللہ عنہ عَنِ النَّبِیِّ ﷺ قَالَ :خَیْرُکُمْ مَنْ تَعَلَّمَ الْقُرْاٰنَ وَعَلَّمَہٗ (صحیح بخاری،502) 3۔عَنْ مَالِکِ بْنِ اَنَسٍ رضی اللہ عنہ قَالَ :قَالَ رَسُوْلُ اللّٰہِ ﷺ: تَرَکْتُ فِیْکُمْ اَمْرَیْنِ لَنْ تَضِلُّوْا مَا تَمَسَّکْتُمْ بِھِمَا کِتَابَ اللّٰہِ وَسُنَّۃَ رَسُوْلِہٖ (رواہ مالک فی المؤطا مرسلاً) 4۔عَنْ عَبْدِ اللّٰہِ بْنِ عُمَرَ رضی اللہ عنہما قَالَ :قَالَ رَسُوْلُ اللّٰہِ ﷺ بُنِیَ الْاِسْلَامُ عَلٰی خَمْسٍ شَھَادَۃِ اَنْ لَّا اِلٰہَ اِلَّا اللّٰہُ وَاَنَّ مُحَمَّدًا عَبْدُہٗ وَرَسُوْلُہٗ وَاِقَامِ الصَّلٰوۃِ وَاِیْتَاءِ الزَّکٰوۃِ وَالْحَجِّ وَصَوْمِ رَمَضَانَ (صحیح مسلم:113) 5۔وَعَنِ النُّعْمَانِ بْنِ بَشِیْرٍ رضی اللہ عنہ قَالَ قَالَ رَسُوْلُ اللّٰہِ ﷺ تَرَی الْمُؤْمِنِیْنَ فِیْ تَرَاحُمِھِمْ وَتَوَادِّھِمْ وَتَعَاطُفِھِمْ کَمَثَلِ الْجَسَدِ اِذَا اشْتَکٰی عُضْوٌ تَدَاعٰی لَہٗ سَائِرُ جَسَدِہٖ بِالسَّھَرِ وَالْحُمّٰی (متفق علیہ، بخاری:6011)

6. عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللهُ عَنْهُ أَنَّ رَسُولَ اللهِ ﷺ قَالَ: أَتَدْرُونَ مَا الْمُفْلِسُ؟ قَالُوا الْمُفْلِسُ فِينَا مَنْ لَا دِرْهَمَ لَهُ وَلَا مَتَاعَ فَقَالَ: إِنَّ الْمُفْلِسَ مِنْ أُمَّتِي مَنْ يَأْتِي يَوْمَ الْقِيَامَةِ بِصَلَاةٍ وَصِيَامٍ وَزَكَاةٍ وَيَأْتِي قَدْ شَتَمَ هَذَا وَقَذَفَ هَذَا وَأَكَلَ مَالَ هَذَا وَسَفَكَ دَمَ هَذَا وَضَرَبَ هَذَا فَيُعْطَى هَذَا مِنْ حَسَنَاتِهِ وَهَذَا مِنْ حَسَنَاتِهِ فَإِنْ فَنِيَتْ حَسَنَاتُهُ قَبْلَ أَنْ يُقْضَى مَا عَلَيْهِ أُخِذَ مِنْ خَطَايَاهُمْ فَطُرِحَتْ عَلَيْهِ ثُمَّ طُرِحَ فِي النَّارِ. (رواہ مسلم، کتاب البر: 6579)

7. عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللهُ عَنْهُ قَالَ كَانَ رَسُولُ اللهِ ﷺ يَقُولُ اللَّهُمَّ إِنِّي أَعُوذُ بِكَ مِنَ الْأَرْبَعِ مِنْ عِلْمٍ لَا يَنْفَعُ وَمِنْ دُعَاءٍ لَا يُسْمَعُ وَمِنْ قَلْبٍ لَا يَخْشَعُ وَمِنْ نَفْسٍ لَا تَشْبَعُ. (رواہ مسلم و احمد، سنن ابن ماجہ: 250)

5. عن أبي هريرة رضي الله عنه قال: قال رسول الله ﷺ كانت بنو إسرائيل تسوسهم الأنبياء كلما هلك نبي خلفه نبي وإنه لا نبي بعدي وسيكون بعدي خلفاء فيكثرون (صحیح البخاری، 3455)

8. عَنْ عَبْدِ اللهِ بْنِ عُمَرَ رَضِيَ اللهُ عَنْهُمَا قَالَ قَالَ رَسُولُ اللهِ ﷺ أَلَا كُلُّكُمْ رَاعٍ وَكُلُّكُمْ مَسْئُولٌ عَنْ رَعِيَّتِهِ فَالْأَمِيرُ الَّذِي عَلَى النَّاسِ رَاعٍ وَهُوَ مَسْئُولٌ عَنْ رَعِيَّتِهِ وَالرَّجُلُ رَاعٍ عَلَى أَهْلِ بَيْتِهِ وَهُوَ مَسْئُولٌ عَنْ رَعِيَّتِهِ وَالْمَرْأَةُ رَاعِيَةٌ عَلَى بَيْتِ زَوْجِهَا وَوَلَدِهِ وَهِيَ مَسْئُولَةٌ عَنْهُمْ وَعَبْدُ الرَّجُلِ رَاعٍ عَلَى مَالِ سَيِّدِهِ وَهُوَ مَسْئُولٌ عَنْهُ أَلَا فَكُلُّكُمْ رَاعٍ وَكُلُّكُمْ مَسْئُولٌ عَنْ رَعِيَّتِهِ (ترمذی: 1705)

9. وَعَنِ النُّعْمَانِ بْنِ بَشِيرٍ رَضِيَ اللهُ عَنْهُ قَالَ قَالَ رَسُولُ اللهِ ﷺ تَرَى الْمُؤْمِنِينَ فِي تَرَاحُمِهِمْ وَتَوَادِّهِمْ وَتَعَاطُفِهِمْ كَمَثَلِ الْجَسَدِ إِذَا اشْتَكَى عُضْوٌ تَدَاعَى لَهُ سَائِرُ الْجَسَدِ بِالسَّهَرِ وَالْحُمَّى (بخاری: 6011)

10. عَنْ عَبْدِ اللهِ رَضِيَ اللهُ عَنْهُ قَالَ: قَالَ رَسُولُ اللهِ ﷺ طَلَبُ كَسْبِ الْحَلَالِ فَرِيضَةٌ بَعْدَ الْفَرِيضَةِ (شعب الایمان بیہقی)

11. عَنْ أَبِي أُمَامَةَ الْبَاهِلِيِّ رَضِيَ اللهُ عَنْهُ عَنِ النَّبِيِّ ﷺ قَالَ لِلْغَازِي أَجْرُهُ وَلِلْجَاعِلِ أَجْرُهُ وَأَجْرُ الْغَازِي مَعَ الدِّينِ وَالصَّدَقَةِ وَالشَّهَادَةِ (جامع ترمذی: 1209)

12. عَنْ أَبِي هُرَيْرَةَ رَضِيَ اللهُ عَنْهُ قَالَ قَالَ رَسُولُ اللهِ ﷺ: اجْتَنِبُوا السَّبْعَ الْمُوبِقَاتِ قَالُوا يَا رَسُولَ اللهِ وَمَا هُنَّ قَالَ: الشِّرْكُ بِاللهِ وَالسِّحْرُ وَقَتْلُ النَّفْسِ الَّتِي حَرَّمَ اللهُ إِلَّا بِالْحَقِّ وَأَكْلُ الرِّبَا وَأَكْلُ مَالِ الْيَتِيمِ وَالتَّوَلِّي يَوْمَ الزَّحْفِ وَقَذْفُ الْمُحْصَنَاتِ الْمُؤْمِنَاتِ الْغَافِلَاتِ (متفق علیہ)

13. ثبت عن رسول الله عليه الصلاة والسلام أنه قال: لا يزني الزاني حين يزني وهو مؤمن، ولا يسرق السارق حين يسرق وهو مؤمن، ولا يشرب الخمر حين يشربها وهو مؤمن، ولا ينتهب نهبةً ذات شرف يرفع الناس إليه فيها أبصارهم حين ينتهبها وهو مؤمن (صحیح البخاری: 6810)

14. عَنْ أَبِي سَعِيدٍ الْخُدْرِيِّ رَضِيَ اللهُ عَنْهُ قَالَ سَمِعْتُ رَسُولَ اللهِ ﷺ يَقُولُ مَنْ رَأَى مِنْكُمْ مُنْكَرًا فَلْيُغَيِّرْهُ بِيَدِهِ فَإِنْ لَمْ يَسْتَطِعْ فَبِلِسَانِهِ فَإِنْ لَمْ يَسْتَطِعْ فَبِقَلْبِهِ وَذَلِكَ أَضْعَفُ الْإِيمَانِ (مسلم: 177)

15. عَنْ أَنَسٍ رَضِيَ اللهُ عَنْهُ قَالَ رَسُولُ اللهِ ﷺ وَالَّذِي نَفْسِي بِيَدِهِ لَا يُؤْمِنُ عَبْدٌ حَتَّى يُحِبَّ لِأَخِيهِ مَا يُحِبُّ لِنَفْسِهِ. (مسلم: 170)

16. وَعَنْ عِمْرَانَ بْنِ حُصَيْنٍ رَضِيَ اللهُ عَنْهُ قَالَ قَالَ رَسُولُ اللهِ ﷺ: خَيْرُ أُمَّتِي قَرْنِي ثُمَّ الَّذِينَ يَلُونَهُمْ ثُمَّ الَّذِينَ يَلُونَهُمْ. (بخاری: 3659)

17. عَنْ جَابِرِ بْنِ عَبْدِ اللهِ رَضِيَ اللهُ عَنْهُ قَالَ: خَطَبَنَا رَسُولُ اللهِ ﷺ وَسْطَ أَيَّامِ التَّشْرِيقِ يَخْطُبُ بِنَاقَةِ الْوَدَاعِ فَقَالَ: يَا أَيُّهَا النَّاسُ إِنَّ رَبَّكُمْ وَاحِدٌ وَإِنَّ أَبَاكُمْ وَاحِدٌ لَا فَضْلَ لِعَرَبِيٍّ عَلَى عَجَمِيٍّ وَلَا لِعَجَمِيٍّ عَلَى عَرَبِيٍّ وَلَا لِأَحْمَرَ عَلَى أَسْوَدَ وَلَا أَسْوَدَ عَلَى أَحْمَرَ إِلَّا بِالتَّقْوَى إِنَّ أَكْرَمَكُمْ عِنْدَ اللهِ أَتْقَاكُمْ أَلَا هَلْ بَلَّغْتُ قَالُوا بَلَّغَ رَسُولُ اللهِ قَالَ فَلْيُبَلِّغِ الشَّاهِدُ الْغَائِبَ فَلْيُبَلِّغِ الشَّاهِدُ الْغَائِبَ. (البیہقی، شعب الایمان، باب فی حفظ اللسان، فصل فی حفظ اللسان عن الفخر بالآباء)

3۔ ایمانیات وعبادات: تعارف اور مختصر۔

4۔ سیرت نبوی صلی اللہ علیہ وآلہ وسلم

1۔ رسول اللہ صلی اللہ علیہ وآلہ وسلم کی حیات طیبہ (حالات زندگی قبل از بعثت، اعلان نبوت، ہجرت مدینہ، غزوات، صلح حدیبیہ، خطبہ حجۃ الوداع)

2۔ رسول اللہ ﷺ کی مختلف حیثیات: (i) بحیثیت معلم (ii) بحیثیت پیغمبر امن

	5۔ خلافتِ راشدہ ۱۔ خلفائے راشدین (حضرت ابو بکر صدیقؓ، حضرت عمر فاروقؓ، حضرت عثمان غنیؓ، حضرت علی المرتضیٰؓ) کے شخصی احوال ۲۔ عہد خلافت راشدہ کے اہم خصائص **6۔ فقہِ اسلامی** 1۔ فقہِ اسلامی کے مآخذ: (قرآن، سنت، 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۔ عالمگیریت اور اس کے مسائل و تقاضے 2۔ اسلاموفوبیا 3۔ تکثیری 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

Title	**Ideology and Constitution of Pakistan**		
Code	**GE-168**		
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
Course Description	**1. 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	**Introduction to Management**

Code	**GE-192**		
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 and apply management principles and concepts as they apply to business situations.	C2 (Understand)	1,3,6,7,9,10
	CLO2: Understand the role of management in making business decisions.	C2 (Understand)	1,3,6,7,9,10
	CLO3: Understand efficiently and effectively working in any kind of organization.	C2 (Understand)	1,3,6,7,9,10
Course Description	**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. **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.		
Text Book(s)	1. Ricky W. Griffin, Management, 12th Edition, Cengage Learning, 2017, ISBN: 1305501292.		
Reference Material	1. Stephen P Robbins, Mary Coulter, Management, 14th Edition, Pearson, 2017, ISBN: 0134527607.		

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 course introduces students with the basic concept of Physics and electronics. Students are also taught Physics laws and other associate topics to prepare them for the advanced level courses in this area. The focus of the course on electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force and many other useful topics.		
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
Course Description	Electric force and its applications and related problems, conservation of charge, charge quantization, Electric fields due to point charge and lines of force. Ring of charge, Disk of charge, A point charge in an electric field, Dipole in a n electric field, The flux of vector field, The flux of electric field, Gauss' Law, Application of Gauss' Law, Spherically symmetric charge distribution, A charge isolated conductor, Electric potential energy, Electric potentials, Calculating the potential from the field and related problem Potential due to point and continuous charge distribution, Potential due to dipole, equipotential surfaces, Calculating the field from the potential, Electric current, Current density, Resistance, Resistivity and conductivity, Ohm's law and its applications, The Hall effect, The magnetic force on a current, The Biot- Savart law, Line of B, Two parallel conductors, Amperes' s Law, Solenoid, Toroids, Faraday's experiments, Faraday's Law of Induction, Lenz's law, Motional emf, Induced electric field, Induced electric fields, The basic equation of electromagnetism, Induced Magnetic field, The displacement current, Reflection and Refraction of light waves, Total internal reflection, Two source interference, Double Slit interference, related problems, Interference from thin films, Diffraction and the wave theory, related problems, Single-Slit Diffraction, related problems, Polarization of electromagnetic waves, Polarizing sheets, related problems.		
Text Book(s)	1. D. Halliday, R. Resnick, Kenneth S. Krane, Physics Vol. 2, 5th Ed., John Wiley, 2001, ISBN: 978-0471401940.		
Reference Material	1. Hugh D. Young, Roger A. Freedman, A. Lewis, Sears, University Physics, 11th Ed., Benjamin-Cummings Pub. Co., 2004, ISBN: 978-0805391794. 2. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, 6th Ed., Wiley, 2010, ISBN: 978-0470469118. 3. Fundamentals of Physics (Extended), 10th edition, Resnick and Walker 4. Narciso Garcia, Arthur Damask, Steven Schwarz., "Physics for Computer Science Students", Springer Verlag, 1998.		

Course Title	**Professional Practices**		
Course Code	**GE-262**		
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: Trace the historical evolution of the computing profession and its impact on society.	C1 (Knowledge)	1,8
	CLO2: Describe the interplay between computing technologies and societal shifts, acknowledging both positive and negative implications.	C2 (Describe)	1,8,9,10
	CLO3: Recognize and explain the core ethical principles that guide the computing profession.	C4 (Identify)	1,8,9,10
	CLO4: Explain the responsibilities of computing professionals in their interactions with society and individuals.	C2 (Explain)	1,8,9,10
	CLO5: Analyze and critically evaluate real-world case studies in computing, assessing them from both ethical and professional viewpoints.	C4 (Analyze)	1,8,9,10
Course Description	Historical, social, and economic context of computing (software engineering, computer science, and information technology); definitions of computing (software engineering, computer science, and information technology) subject areas and professional activities; professional societies; professional ethics; professional competency and life-long learning; uses, misuses, and risks of software; information security and privacy; business practices and the economics of software; intellectual property and software law (cyber law); social responsibilities; software-related contracts; software house organization. Intellectual property rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse, and the Criminal Law, Regulation, and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct, and the ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.		
Text Book(s)	1. Michael J. Quinn, Ethics for the Information Age, 7th Edition, Pearson Education, 2017, ISBN: 978-0134296548 2. Sara Baase, A Gift of Fire: Social, Legal, and Ethical Issues in Computing, 5th Edition, Pearson, 2018, ISBN: 978-0132492676		
Reference Material	1. J. Kizza, Ethical and Social Issues in the Information Age, 6th Edition, Springer, 2017, ISBN: 978-3319707112 2. "Professional Issues in Software Engineering" by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, 3rd Edition, CRC Press, 2000. ISBN-10: 0748409513 3. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition, 2009. ISBN-10: 0131112414		

Title	**Civics and Community Management**		
Code	**GE-363**		
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 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
Course Description	**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.		
Text Book(s)	1. "Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education 2. "Citizenship in Diverse Societies" by Will Kymlicka and Wayne Norman. 3. "Digital Citizenship in Action: Empowering Students to Engage in Online Communities" by Kristen Mattson. 4. "Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education" by Graham Pike and David Selby.		
Reference Material	1. "Community Engagement: Principles, Strategies, and Practices" by Becky J. Feldpausch and Susan M. Omilian. 2. "Creating Social Change: A Blueprint for a Better World" by Matthew Clarke and Marie-Monique Steckel.		

Course Title	**Entrepreneurship**		
Code	**GE-362**		
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)	At the end of the course, the students will be able to:	**BT**	**PLO**
	CLO1: Knowledge of fundamental entrepreneurial concepts, skills and process	C1 (Knowledge)	1
	CLO2: Understanding of different personal, social and financial aspects associated with entrepreneurial activities	C2 (Understand)	1,3,10
	CLO3: Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on exports	C2 (Understand)	1,3,10
	CLO4: Ability to apply knowledge, skills and abilities acquired in the course to develop a feasible business plan for implementation	C5 (Create)	4,5,6,10
Course Description	**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 such as creative and critical thinking innovation and risk taking. **Opportunity Recognition and Idea Generation:** Opportunity identification, evaluation and exploitation, Innovative ideas generation techniques for entrepreneurial ventures. **Marketing and sales:** Four P's of Marketing, Developing a marketing strategy, Branding. **Financial Literacy:** Basic concepts of income, savings and investments, Basic concepts of assets, liabilities and equity, Basic concepts of revenue and expenses, Overview of cash-flows, Overview of banking products including Islamic modes of financing, Sources of funding for startups (angel financing, debt financing, equity financing etc.) **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.		
Practical Requirements	As part of the overall learning requirements, students shall be tasked with creating and presenting a comprehensive business plan at the end of the course for a hypothetical or real business idea. This practical exercise shall allow them to apply the knowledge, skills and abilities acquired in the course to develop a feasible business plan and where possible explore the possibility of implementing the plan with support and assistance from established business-persons and entrepreneurs.		
Suggested Instructional/ Reading Material	1. B. R. Barringer, and R. D. Ireland, Entrepreneurship: Successfully Launching New Ventures, 6th Edition, Prentice Hall, 2019, ISBN: 978-0134729534. 2. "Entrepreneurship: Theory, Process, and Practice" by Donald F. Kuratko. 3. "New Venture Creation: Entrepreneurship for the 21st Century" by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.		

	4. "Entrepreneurship: A Real-World Approach" by Rhonda Abrans. 5. "The Lean Startup: How Today's Entrepreneurs use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries. 6. "Effectual Entrepreneurship" by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valcric Ohlsson.

UNIVERSITY ELECTIVE: 3 (3, 0)
ANY ONE COURSE FROM THE FOLLOWING NON-EXHAUSTIVE LIST OF COURSES

Sr.	Code	Course Title	Prerequisite	Cr. Hrs.
1.	UE-272	Introduction to Marketing		3 (3,0)

Course Title	**Introduction to Marketing**		
Course Code	**UE-272**		
Credit Hours	3 (3,0)		
Category	Elective Supporting Course		
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.		
Text Book(s)	1. Kotler P., Armstrong G., Agnihotri P. Y., and Ehsan Ul Haque. 2017. Principles of Marketing: A South Asian Perspective. 13th Ed. Pearson Education, India.		
Reference Material	1. Sharp B. 2018. Marketing: Theory, Evidence, Practice. 2nd ed. Oxford University Press.		