Department of Computer Science and Engineering

Program: Masters

New Syllabus of

Master of Science in Computer Science and Engineering

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CURRICULUM (OBE)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING,
UNIVERSITY OF ASIA PACIFIC
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CONTENTS

PART A: PROGRAM OUTLINE

PART B: STRUCTURE OF THE CURRICULUM

PART C: DESCRIPTION OF ALL COURSES

PART D: GRADING/EVALUATION

PART A: PROGRAM OUTLINE

1.1. Title of the Academic Programs

Master of Science in Computer Science and Engineering (M.Sc. in CSE)

1.2 Name of the University

University of Asia Pacific (UAP)

University at a Glance

University of Asia Pacific (UAP) is a government approved private university established by the University of Asia Pacific Foundation (UAPF). UAP was established in 1996 as a private university under the Private University Act 1992, with a vision to enhance the opportunities for higher education in Bangladesh. The curriculum of UAP has been approved by the University Grants Commission (UGC) of the GoB. The university started its operation in 1996 and offered four years bachelor degree programs in Computer Science and Engineering and Business Administration. At present UAP offers undergraduate programs in nine disciplines and graduate programs in eight disciplines.

UAPF is a non-profit, non-commercial foundation based in Dhaka, Bangladesh. The principal aim of the foundation is to promote human and social development through improved educational opportunities, innovative educational programs relevant to the needs of an emerging society and to develop skills, know-how and awareness of the youth through appropriate institutional grooming. The foundation has been established by a group of eminent educationists, industrialists, and administrators who share the same vision and social commitments. UAP is the first project of the foundation aimed at realizing these noble goals.

The main objective of UAP is to provide high quality education at tertiary level relevant to the demands of a high-quality dynamic academia in Bangladesh. The courses and curricula are designed to enable and equip a student to enter into the national and international job market or pursue higher academic and professional goals with a solid academic foundation. The sole objective of the university is not to make the students pass the exam only. The university equips its students with the means to become productive and proactive members of the community and continue the practice of continuous learning to become future leaders and useful members of the society.

1.3 Vision of the University

UAP steadfastly holds its passion to do better and better in fulfilling our young generation's needs and aspirations for a caring and quality education in casting their future career and becoming a desirable destination for an identity.

1.4 Mission of the University

The mission of UAP is to offer the best possible education to our young generation. Towards the fulfillment of the mission, UAP continues to develop a sustained culture of ascending to a top- tier of vibrant academic environment; maintain and foster well qualified faculty, provide adequate research support for cutting-edge research in-house and in collaboration national and international peers; update curricula to keep up with the advancing trend in science and technology, use state-of-the-art practices in teaching-learning and modern facilities in laboratories and libraries; and provide other supports in aid to the students becoming competent graduates with their potential fully realized and personality well-developed for joining the global forces in making a better future for the society in changing world.

1.5 Name of the Faculty Offering the Program

Department of Computer Science and Engineering under School of engineering is offering this program.

At a Glance

The University of Asia Pacific's Department of Computer Science and Engineering proposes that the Master of Science in Computer Science and Engineering (abbreviated as M. Sc. in CSE) syllabuses be updated to reflect recent advances in the respective fields. The postgraduate program has multiple goals, including improving graduate engineers' knowledge so that they can meet the various challenges in the field of computer science and engineering, solving national and international problems, and creating new knowledge through research activities., and disseminate the new knowledge through lectures, seminars, conferences, and workshops.

1.6 Vision of the Department of CSE: The department of Computer Science and Engineering (CSE), University of Asia Pacific (UAP) is striving for a pioneer role in ICT through excellence in education, research and development towards preparing graduates as a global leader with quality education, innovative ideas,

extracurricular activities and collaboration between industry and academia.

1.7 Mission of the Department of CSE: Department of CSE believes in the pursuit of excellence by developing students in creating, applying and imparting knowledge of ICT. Educational curriculum, research and collaboration between academia and industry are given highest priority. Department of CSE, UAP aspires to produce graduates capable of taking leadership in the field of their best interest. We nurture graduates in

• Understanding the basic principles of computational, electric and modern technologies

• Promoting creativity by applying their theoretical knowledge in practical problem solving

• Enabling them to communicate ideas clearly and concisely both written and verbally

• Creating awareness about environment, social context, and economic development within the ethical boundaries

• Engaging for further research or professional involvement.

1.8 Credit Structure and Course Pattern

To achieve a major in a particular track (see Section 3.1) a student must fulfill the course requirements as described in Table 6.

Table 1: Master of Science in Computer Science and Engineering (M.Sc. in CSE)

Course Category	**Number of Courses**	**Credit**
Two courses from each Track	8x3	8x 3.0 =24.0
Thesis		12.0
One Non-credit course		0
Total		36.0
Selection of Major: If two or more courses and the topic of Thesis are selected from a particular track, a student will be awarded the degree with a major of that track.		

1.9 Statements of Program Educational Objectives (PEOs) of the Department of CSE

PEOs	PEO Statements
PEO1	Understand and possess theoretical and practical advanced knowledge of Computer Science and Engineering to establish successful computing or engineering careers in industry, government, and academia that will advance the economic development of the country, the region, and beyond.
PEO2	Ability to implement the knowledge for software industry, public and private sectors, cyber security, big data analyst, advanced Artificial Intelligence and expert system with a highly professional and ethical attitude.
PEO3	Enhance skills and creativity to investigate the performance resource requirements of various algorithms on different fields of Computer Systems, Intelligent Computing and Data Science, Network and Security, and Software Engineering.
PEO4	Encourage the students to participate in a life-long learning process for a highly productive career and to relate the concepts of Computer Sciences towards fourth industrial revolution (4 IR).

1.10 Statements of Program Learning Outcomes (PLOs) of the Department of CSE

PLOs	Statements	Differentiating Characteristics
PLO1	**Engineering Knowledge**	Apply knowledge of mathematics, sciences, engineering fundamentals and manufacturing engineering to the solution of complex engineering problems.
PLO2	**Problem Analysis**	Identify, formulate, research relevant literature and analyze complex engineering problems, and reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO3	**Design/Development of Solutions**	Design solutions, exhibiting innovativeness, for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, economical, ethical, environmental and sustainability issues.
PLO4	**Investigation**	Conduct investigation into complex problems, displaying creativeness, using research-based knowledge, and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
PLO5	**Modern Tool Usage (A & D)**	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations
PLO6	**The Engineer and Society (ESSE)**	Apply reasoning based on contextual knowledge to assess societal, health, safety, legal, cultural, contemporary issues, and the consequent responsibilities relevant to professional engineering practices.
PLO7	**Environment and Sustainability (ESSE)**	Understand the impact of professional engineering solutions in societal, global, and environmental contexts and demonstrate knowledge of and need for sustainable development;
PLO8	**Ethics (ESSE)**	Apply professional ethics with Islamic values and commit to responsibilities and norms of professional engineering code of practices.
PLO9	**Individual and Team Work**	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
PLO10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions;
PLO11	**Project Management and Finance**	Demonstrate knowledge and understanding of engineering management and financial principles and apply these to one's own work, as a member and/or leader in a team, to manage projects in multidisciplinary settings, and identify opportunities of entrepreneurship.

PLO12	**Lifelong Learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

1.11 Mapping of Mission of the University with PEOs

Mission statement	**PEO1**	**PEO2**	**PEO3**	**PEO4**
To offer the best possible education to our young generation	√	√	√	√

1.12 Mapping of PLOs with the PEOs

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**	**PLO12**
PEO1	√	√	√	√	√	√	√					
PEO2		√		√	√						√	√
PEO3	√	√						√	√	√		√
PEO4					√	√	√			√	√	√

1.13 Mapping of Courses Track I: Computer Systems with the PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CSE 6001	√	√	√	√	√	√	√	√	√	√	√	√
Track I												
CSE 6101	√						√			√		
CSE 6103	√				√		√			√		
CSE 6105	√		√		√		√					
CSE 6107	√				√		√			√		
CSE 6109	√				√		√			√		
CSE 6111	√	√						√		√		
CSE 6113	√	√	√					√		√		
CSE 6115	√	√	√					√		√		
CSE 6117	√			√				√		√		
CSE 6119	√											
CSE 6121	√	√	√	√	√			√	√	√		√

1.14 Mapping of Courses Track II: Intelligent Computing and Data Science with the PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CSE 6001	√	√	√	√	√	√	√	√	√	√	√	√
Track II												
CSE 6201	√						√			√		
CSE 6203	√				√		√			√		
CSE 6205	√		√		√		√					
CSE 6207	√		√		√		√			√		
CSE 6209	√				√		√			√		
CSE 6211	√	√						√		√		
CSE 6213	√	√	√							√		
CSE 6215	√	√	√							√		
CSE 6217	√			√				√		√		
CSE 6219	√			√						√		
CSE 6221	√			√						√		
CSE 6223	√									√		

1.15 Mapping of Courses Track III: Network and Security with the PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CSE 6001	√	√	√	√	√	√	√	√	√	√	√	√
Track III							√					
CSE 6301	√						√			√		
CSE 6303	√				√		√			√		
CSE 6305	√		√		√		√					
CSE 6307	√		√				√			√		
CSE 6309	√	√			√		√			√		
CSE 6311	√	√	√		√			√		√		
CSE 6313	√	√	√					√		√		
CSE 6315	√	√	√							√		
CSE 6317	√	√		√				√		√		
CSE 6319	√			√				√		√		
CSE 6321	√					√				√		
CSE 6323	√					√				√		
CSE 6325	√									√		

1.16 Mapping of Courses Track IV: Software Engineering with the PLOs

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CSE 6001	√	√	√	√	√	√	√	√	√	√	√	√
Track IV												
CSE 6401	√						√			√		
CSE 6403	√				√		√			√		
CSE 6405	√		√		√		√					
CSE 6407	√		√		√		√			√		
CSE 6409	√				√		√			√		
CSE 6411	√	√	√					√		√		
CSE 6413	√	√	√					√		√		
CSE 6415	√	√	√					√		√		
CSE 6417	√	√		√				√		√		
CSE 6419	√	√		√				√		√		
CSE 6421	√			√						√		
CSE 6423	√					√			√	√		
CSE 6425	√	√	√			√		√	√	√		
CSE 6427	√	√	√			√		√		√		
CSE 6429	√			√				√		√		
CSE 6431	√			√					√	√		
CSE 6433	√			√					√	√		

PART B: STRUCTURE OF THE CURRICULUM

2.1 Structure of the Curriculum

All the postgraduate studies issues will be administered by the Board of Post Graduate Studies (BPGS), CSE, UAP. The BPGS will be constituted by the following members:

i. Head of the Department — Chairman

ii. Three faculty members from the CSE department not below the rank of Assistant Professor — Members

iii. Master's Coordinator — Member Secretary

2.2 Major tracks of M. Sc. in CSE

The courses of M. Sc. in CSE will be offered in four different major tracks. A student can select a major track based on his/her interest.

- **Track I** : Computer Systems
- **Track II** : Intelligent Computing and Data Science
- **Track III** : Network and Security
- **Track IV** : Software Engineering

Section 1.8 explains the rules for achieving a major track

2.3 Total Minimum Credit Requirements

A student needs to complete a total of 36 credit hours for the M. Sc. in CSE as the requirement of her/his degree fulfillment. The total credit hours are distributed in the following manner according to the degree:

Table 2.1: Credit Requirements

Degree Name	Theory (credit hours)	Thesis (credit hours)	Total (credit hours)
M. Sc. in CSE	24.0	12.0	36.0

2.4 Admission Requirements

For admission to the courses leading to a master's degree, M. Sc. in CSE, a candidate needs to satisfy the following requirements:

I. Obtained a B. Sc. Engr./ B.Sc. honors degree in the relevant branch or an equivalent degree from any recognized institution.

II. A student with a Bachelor's degree in any branch of faculty of science, business studies, social sciences, etc. from any recognized institution may be allowed to take admission with permission from the BPGS, CSE, UAP to pursue M. Sc. in CSE. They may need to complete prerequisite courses prescribed by the BPGS from the courses listed in Section 2.4.1.(Table 2.2).

III. No third division/class or less than 2.50 out of 4.00 CGPA in any examination.

2.4.1 Prerequisite Courses

Table 2.2: Prerequisite Courses

Course Code	Course Title	Credit Hours
CSE 103	Structured Programming	3.00
CSE 105	Discrete Mathematics	3.00
CSE 203	Object Oriented Programming	3.00
CSE 205	Data Structure	3.00
CSE 209	Digital Logic & System Design	3.00
CSE 207	Algorithms	3.00
CSE 211	Database Systems	3.00
CSE 307	Theory of Computation	3.00
CSE 311	Microprocessors & Assembly Language	3.00
CSE 313	Numerical Methods	3.00
CSE 317	Computer Architecture	3.00
CSE 319	Computer Networks	3.00
CSE 403	Artificial Intelligence and Expert Systems	3.00
CSE 405	Operating Systems	3.00
CSE 425	Computer Graphics	3.00

MTH 101	Math I: Basic Calculus, Coordinate Geometry	3.00
MTH 103	Math II: Linear Algebra	3.00
MTH 203	Probability & Statistics	3.00

2.5 Admission Procedures

I. Application for admission to the postgraduate courses shall be invited through regular means of advertisement by the Registrar of the university. Before being finally selected for admission, a candidate may be required to appear at an oral and/or written test by a Selection Committee as constituted by the Head of the Department. The student will be required to take prerequisite courses as may be prescribed by the BPGS. Every selected candidate, unless she/he has already been registered, shall get herself/himself registered with the university.

II. After admission, each student will be allocated an Advisor by the BPGS among the Department's teachers who are not below the rank of Assistant Professor. The Advisor must examine and approve the total credit hours prior to each enrollment and course registration for any semester. On all academic matters, the student is expected to consult with his Advisor. However, it is the individual student's responsibility to ensure that his schedule conforms with academic rules.

III. Before the commencement of each semester, every registered student must enroll by paying the required fees and other dues in accordance with university rules. In an academic year, there will be two semesters. Within two weeks of the semester's commencement, all course registration must be completed. Otherwise, the student will not be permitted to finish the semester's course.

2.6 Academic Requirements and Regulations

I. The minimum duration of the M. Sc. in CSE course shall normally be three semesters. A candidate for the Master’s degree must complete all the requirements for the degree within five academic years from the date of the first admission in the respective program. Each academic year is comprised of two semesters, i.e., Spring and Fall. The duration of each regular semester is generally 18 weeks, which is organized in the following way:

Classes	14 weeks
Midterm Examination	1 week
Recess before Final Examination	1 week
Final Examination	2 weeks
Total	18 weeks

II. Academic progress is measured in terms of credit hours earned by a student. One credit hour course requires one hour of class attendance per week.

III. One credit hour of thesis requires 0.5 contact hours of work per week. For example, six credit hours of thesis will require 3 contact hours per week with the supervisor.

IV. For the degree of M. Sc. in CSE a student must earn a minimum of 36 credit hours including thesis.

V. There are two categories of students, namely, full-time students and part-time students.

VI. Students serving in different organizations may be admitted as part-time students with the written consent of the employer. A part-time student may be assigned a maximum of 09 credit hours of course including thesis work in any semester.

VII. Full-time students must register for a minimum of 6 credit hours and a maximum of 9 credit hours per semester. They may be employed as a teaching/research assistant at the university. If a full-time student is an employee (full time or part-time) of any organization she/he may with the approval of the Head of the Department of CSE and his/her employer be allowed as a full-time student.

VIII. The courses of study in the Department have been recommended by the Board of Post Graduate Studies (BPGS) and approved by the Academic Council (AC). The BPGS may conduct periodic reviews of the curriculum and make any adjustments that are deemed necessary. The BPGS will also determine which courses will be offered in any given semester.

IX. A student on the recommendation of the BPGS and as approved by the Equivalence Committee of UAP may be allowed to transfer credits of the courses completed by the student at a recognized institution provided that the courses were not taken earlier than five calendar years from the date of his first enrolment in the respective program at UAP and that the student obtained a minimum GPA of 2.5 out of 4.0 or its equivalent and that the courses are equivalent to the approved courses of UAP.

X. On the recommendation of the BPGS and Academic Council (AC), the rules for admission into the University for Postgraduate Studies shall be framed from time to time by the Academic Council. Academic Council on its own may, if it deems fit, recommend such rules for admission for approval of the Academic Council.

2.7 Thesis Defense Policy for the MCSE Programs

I. Thesis work must be completed under the direct supervision of a full-time CSE department faculty member. However, in special cases, a full-time faculty member other than CSE department may also be appointed as supervisor.

II. The student has to verify that the thesis was written by him or her and this work has not been submitted elsewhere for any other degree.

III. Students must submit their thesis to the Master's Coordinator through supervisors before the deadline of final presentation and viva. The date of the final presentation and viva-voce will be determined by the examination committee of the department.

IV. Students must have to present their thesis/ research update at the end of the 2nd semester and must have to defend their thesis in front of the examination committee at the end of the 3rd semester.

V. Thesis marks distribution will be as below

Thesis/ Research update (Pre-defense) = 30% of total marks (from supervisor)
Final defense = 70% of total marks
(50% from supervisor & 20% from Examination board)

VI. Thesis evaluation committee/board worth a maximum of five members will be formed by the master's coordinator upon the approval from Head of the department. The members of the board shall include MCSE thesis supervisors, Master's coordinator and Head of the department.

VII. Rubrics will be provided for thesis evaluation.

PART C: DESCRIPTION OF ALL COURSES

3.1 Graduate Courses

Explanation of Graduate course numbering system: It consists of 4 digits **($X_4 X_3 X_2 X_1$)** and details are given below:

Table 3.1: Course Numbering Explanation			
X_4	X_3	X_2	X_1
6 = Graduate Course	0 = Theis/Project 1 = Track I: Computer System 2 = Track II: Intelligent Computing and Data Science 3 = Track III: Network and Security 4 = Track IV: Software Engineering	01, 03, … = Course number	

Table 3.2: Graduate Courses		
Course Code	**Course Title**	**Credit Hours**
	M. Sc. in CSE	
CSE 6001	Thesis	12.00
CSE 6003	Research Methodology	0.00
Track I: Computer Systems		
CSE 6101	Advanced Algorithm	3.00
CSE 6103	Advanced Microprocessor	3.00
CSE 6105	Advanced Database Management System	3.00
CSE 6107	Dependable and Fault-Tolerant Computer Systems	3.00
CSE 6109	Graph Theory	3.00
CSE 6111	Computer Systems Performance Analysis	3.00
CSE 6113	Advanced Operating Systems	3.00
CSE 6115	Distributed Computing	3.00
CSE 6117	Cloud Computing	3.00
CSE 6119	Courses of Current Interest/Special Topics Related to Computer System	3.00
Track II: Intelligent Computing and Data Science		
CSE 6201	Advanced Artificial Intelligence and Expert System	3.00
CSE 6203	Computer Vision	3.00
CSE 6205	Machine Learning	3.00
CSE 6207	Deep Learning	3.00
CSE 6209	Natural Language Processing	3.00
CSE 6211	Data Science	3.00
CSE 6213	Big Data	3.00
CSE 6215	Business Intelligence	3.00
CSE 6217	Robotics	3.00

CSE 6219	Bioinformatics	3.00
CSE 6221	Human Computer Interaction	3.00
CSE 6223	Courses of Current Interest/Special Topics Related to Intelligent Computing and Data Science	3.00
Track III: Network and Security		
CSE 6301	Cryptography	3.00
CSE 6303	Network Security	3.00
CSE 6305	Information System Security Management	3.00
CSE 6307	Computer Communications and Networks	3.00
CSE 6309	Advanced Wireless and Mobile Networks	3.00
CSE 6311	Fiber Optic Communications System	3.00
CSE 6313	Data Management in Cloud	3.00
CSE 6315	Blockchain Technology	3.00
CSE 6317	Internet of Things (IoT)	3.00
CSE 6319	Ethical Hacking	3.00
CSE 6321	Cyber Crime and Digital Forensic	3.00
CSE 6323	Cyber Security and ICT Law	3.00
CSE 6325	Courses of Current Interest/Special Topics Related to Network and Security	3.00
Track IV: Software Engineering		
CSE 6401	Software Design and Integration	3.00
CSE 6403	Software Project Management	3.00
CSE 6405	Software Quality Assurance	3.00
CSE 6407	Software Testing	3.00
CSE 6409	Software Architecture	3.00
CSE 6411	Object Oriented Analysis and Design	3.00
CSE 6413	Advanced Object-Oriented Programming	3.00
CSE 6415	Information System and Business Process	3.00
CSE 6417	E-Commerce and Web Engineering	3.00
CSE 6419	Design & Development of Open Multi-Tier Application	3.00
CSE 6421	Interactive Multimedia Design and Development	3.00
CSE 6423	Computer Graphics and Animation	3.00
CSE 6425	Smart Phone Application Development	3.00
CSE 6427	Computer Game Design and Development	3.00
CSE 6429	Enterprise Resource Planning	3.00
CSE 6431	Engineering Ethics	3.00
CSE 6433	Courses of Current Interest/Special Topics Related to Software Engineering	3.00

3.2 Non-Credit Courses

CSE6003 Research Methodology is a non-credit course in this program.

3.3 Course Details

Track I: Computer Systems

Course No: CSE 6101
Course Title: Advanced Algorithms
Credit: 3.00

Course Content:

Randomized Algorithms: Inequalities and sampling, Las Vegas and Monte Carlo algorithms, K-SAT; **Data structures:** Fibonacci heaps, Splay trees, Dynamic trees; **Approximation algorithms:** Bin packing, Vertex Cover, Travelling Salesman Problems, Bipartite and weighted bipartite matching, Min cut Max flow theorem, Ford Fulkerson algorithm; **Online Algorithms:** Competitive analysis, Online paging problem, *k*-server problem, External memory algorithms, Streaming and compression algorithms, Convex Hull, Voronoi diagram; **Parallel and Distributed Algorithms**: MapReduce, Parallel Prefix Sum, and distributed consensus algorithms; **Evolutionary Algorithms**: Genetic Algorithms, Particle Swarm Optimization, Simulated Annealing, Ant Colony Optimization.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Relate** the fundamentals of advanced algorithms
CLO2	**Analyze** the fundamentals of advanced algorithms and data structures
CLO3	**Investigate** the approximation algorithms
CLO4	**Develop** exact algorithms
CLO5	**Develop** approximate algorithms

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy:

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

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4. Sara Baase, Allen Van Gelder, Addison-Wesley, 3rd Edition, 19992. Rajeev Motwani, and Prabhakar Raghavan. Randomized algorithms. Cambridge university press, 2000.
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Course No: CSE 6103
Course Title: Advanced Microprocessor
Credit: 3.00

Course Content:

Intel 8086: Features and Internal architecture, Memory segmentation, Physical address generation, Register set, Flag register, Pin functions, Minimum mode and maximum mode configurations, Sources of interrupts: interrupt response, interrupt vector table, Types of interrupts addressing mode, Data addressing modes, Classification of instructions, Assembler, Assembler directives, Commonly used assembler directives (ASM 86), Simple assembly language programs. Intel 80386: Internal architecture, Operating modes, Paging mechanism, Address translation in PVAM (non paged and paged modes), Features of Pentium processor, Internal architecture of Pentium processor, List of operating modes, Features of Pentium-Pro processor. Hyper threading technology, Define core, Limitations of single core processor, Concept of multi core processing, Advantages, Homogeneous and heterogeneous multicore processors, Single core and multicore processors comparison, Major issues in multicore processing, Internal architecture of Intel Core2 Duo (Simple block diagram), Important technological features of IA processors, comparison of Core i3, i5 and i7 processors. **Intel 8051**: Block diagram of 8051, facilities of 8051, internal architecture of 8051, Addition using 8051, copy using 8051, Assembly code to Hex code conversion, Hex code placement in ROM, Registers of 8051, memory banks, switching among memory

banks, default memory bank, position and size of stack, accessing of stack, different portions of ram, bit addressable ram, accessing bit addressable ram, addressing mode for programming 8051, Ports of 8051, dual functionalities of the ports.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Define** the Intel 8086 and Intel 8051 architectures
CLO2	**Illustrate** the fundamentals of Intel 8086 and Intel 8051 processors
CLO3	**Develop** understanding regarding the Intel Pentium processors
CLO4	**Analyze** single-core and multi-core processors
CLO5	**Evaluate** Intel core i3, core i5, and core i7 processors

Mapping of CLOs to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy:

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Douglas V. Hall, Microprocessors and interfacing: programming and hardware. McGraw-Hill, Inc.
2. Lyla B. Das,The X86 Microprocessor, 2nd edition. Pearson Education India, 2014.
3. Yu-Cheng Liu, and Glenn A. Gibson. Microcomputer systems: The 8086/8088 family: Architecture, programming, and design. Prentice-Hall, Inc., 2000.
4. Microprocessor 8086 Programming & Interfacing - A Nagoor Kani - RBA Publications.
5. Barry B, Brey, Prentice Hall, 8th Edition, 2008, The Intel Microprocessors 8086/8088, 80/86 80188 80286, 80386, 80486, Pentium and Pentium Processor.

Course No: CSE 6105
Course Title: Advanced Database Management System
Credit: 3.00

Course Content:

Theory: Relational Model Issues: ER model, Normalization, Query processing, Query optimization, Transaction processing, Concurrency control, Recovery, Database tuning, Distributed Databases: Parallel databases, Inter and Intra query parallelism, Distributed database features, Distributed database architecture, Fragmentation, Distributed query processing, Distributed transactions processing, Concurrency control, Recovery, Commit protocols, Object Oriented Databases: Introduction to object oriented databases, Approaches, Modeling and Design, Persistence, Query Languages, Transaction, Concurrency, Multi version locks, Recovery, POSTGRES, JASMINE, GEMSTONE, ODMG Model, Emerging systems: Enhanced data models, Client/Server model, Data warehousing and Data mining, Web databases, Mobile databases, XML, Current Issues: Rules, Knowledge bases, Active and Deductive databases, Multimedia databases, Multimedia data Structures, Multimedia query languages, Spatial databases. New database applications and architectures: e.g. Data Warehousing; Mobility; NoSQL, Native XML databases (NXD), Document orientated databases, Database security -Data Encryption, redaction, and masking techniques. Authentication and authorization. Database auditing

Empirical Study: Instructor may choose any suitable database management systems software such as Oracle RDBMS, IBM DB2, Microsoft SQL Server, MySQL, Microsoft Access, SQLite, PostgresSQL, MongoDB and assign a database management projects to implement the following ideas:

· Creation of a database and writing SQL queries to retrieve information from the database.
· Performing Insertion, Deletion, Modifying, Altering, Updating and Viewing records based on conditions.
· Creation of Views, Synonyms, Sequence, Indexes, save point.

· Creating an Employee database to set various constraints.
· Creating a relationship between the databases.
· Study of PL/SQL block.
· Write a PL/SQL block to satisfy some conditions by accepting input from the user.
· Write a PL/SQL block that handles all types of exceptions.
· Creation of Procedures.
· Creation of database triggers and functions

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the relational database systems
CLO2	**Develop** the Entity-Relationship (ER) model
CLO3	**Understand** the concept of distributed database management system
CLO4	**Explain** the applications with relational database management system
CLO5	**Analyze** different database management systems

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy:

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Christopher John. Date, An introduction to database systems. Pearson Education India,
2. Abraham Silberschatz, Henry F. Korth, and Shashank Sudarshan. Database system concepts. New York: McGraw-Hill,
3. Wilfried Lemahieu, Seppe vanden Broucke, and Bart Baesens. Principles of database management: The practical guide to storing, managing and analyzing big and small data. Cambridge University Press, 2018.
4. Thomas M. Connolly, and Carolyn E. Begg. Database systems: a practical approach to design, implementation, and management. Pearson Education, 2005.
5. Jim. Melton, Advanced SQL: 1999: Understanding object-relational and other advanced features. Morgan Kaufmann, 2003.
6. SQL: The Ultimate Guide from Beginner to Expert -Learn and Master SQL in No Time, Addison Wesley, Peter Adams
7. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems, Martin Kleppmann, O'Reilly

Course No: CSE 6107
Course Title: Dependable and Fault-Tolerant Computer Systems
Credit: 3.00

Course Content:

Theory: Theory of dependability and fault-tolerance, system view of high availability design; Analytical modeling of system reliability; **Fault-Tolerant Design Principles**: Redundancy techniques (hardware, software, information); error detection and correction mechanisms; error recovery strategies. **Fault-Tolerant Architectures**: N-modular redundancy, Triple Modular Redundancy (TMR), voter-based architectures; Byzantine fault tolerance (BFT); distributed fault tolerance. **Reliability Modeling and Analysis**: Probabilistic models (Markov, fault trees); Monte Carlo simulation; software reliability modeling; **Enhancing fault tolerance**: hardware-centric enhancement, fault tolerance using software; **Network fault tolerance**; Error detection techniques: check pointing, different error recovery techniques; **Evaluation of fault tolerance**: experimental approaches, other state-of-the-art approaches, **Resilient Computing**: Resilience engineering principles; cybersecurity aspects; adaptation and self-healing mechanisms.

Empirical Study:

· Practical fault tolerant systems: Amazon Web Service (AWS), Hadoop (or any novel system)

· Network fault tolerance: Bitcoin

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of fault-tolerance system
CLO2	**Calculate** the error recovery techniques
CLO3	**Understand** the hardware-centric fault-tolerance
CLO4	**Examine** network fault-tolerance system
CLO5	**Improve** a network fault-tolerance system

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

Reference:

1. Behrooz Parhami, "Dependable computing: A multilevel approach." Publisher and date TBD, available at:/www. ece. ucsb. edu/~ parhami (2015).
2. Israel Koren, and C. Mani Krishna. Fault-tolerant systems. Morgan Kaufmann, 2020.
3. Verissímo, Paulo and Rodrigues, Luís. Distributed Systems for System Architects, Kluwer Academic Publishers, 2001, ISBN 0-7923-7266-2.
4. Tanenbaum, Andrew S and Van Steen, Martin. Distributed Systems: Principles and Paradigms. Prentice Hall, 2002, ISBN: 0130888931.

Course No: CSE 6109
Course Title: Graph Theory
Credit: 3.00

Course Content:

Fundamental Concepts: Basic definitions, paths, cycles, trails, degree, directed graphs; **Trees and Distance**: Basic properties, spanning trees and enumeration, optimization; Matchings and Factors: Bipartite matching (BPM), Weight BPM, Vertex cover; **Connectivity and Paths**: Cuts, connectivity, k-connected graphs, network flow; **Coloring of Graphs**: Vertex colorings, structure of k-chromatic graphs, enumerative aspects; **Planar Graphs**: Embeddings and Euler's formula, characterizations and parameters of planarity; **Graph Pebbling**: A mathematical model for the transportation of consumable resources, History, pebbling number, Class 0 graphs.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the graph terminologies and different types of graphs
CLO2	**Explain** the fundamentals of graph theory
CLO3	**Identify** the different graph algorithms
CLO4	**Develop** graph algorithms
CLO5	**Analyze** graph algorithms

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

Reference:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. "Introduction to Algorithms (3rd edition)." MIT Press and McGraw-Hill (2009).
2. Bollobás, Béla. Modern graph theory. Vol. 184. Springer Science & Business Media, 2013.
3. Douglas B. West, Introduction to Graph Theory, Pearson Education, 2nd Edition, 2000.
4. Ddgar G. Goodaire, Michael M. Parmenter, Discrete Mathematics with Graph Theory, Pearson Education, 3rd Edition, 2005.
5. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India Pvt.Ltd, 2004.

Course No: CSE 6111
Course Title: Computer Systems Performance Analysis
Credit: 3.00

Course Content:

Theory: Performance evaluation techniques, selection criteria and applicability; **Capacity Planning**: Capacity of a system, concept of adequate capacity, Service Level Agreement (SLA), Methodology for capacity planning; **Performance Measurement**: Workload selection, characterization and forecasting, performance modeling and prediction, **Instrumentation**; Analytic models: operational analysis, stochastic queuing network analysis; Principles of scalable performance. **Empirical Study**: Performance of Client-Server architectures, Peer Assisted file distribution, Time-Energy Performance of Heterogeneous Systems.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of performance analysis techniques
CLO2	**Illustrate** the fundamentals of performance measurement
CLO3	**Compute** the capacity of a system
CLO4	**Develop** performance modeling and prediction system
CLO5	**Evaluate** operational performance models

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Raj. Jain, The art of computer systems performance analysis: techniques for experimental design, measurement, simulation, and modeling. John Wiley & Sons, 1990

2. Lilja, David J. Measuring computer performance: a practitioner's guide. Cambridge university press, 2005.

3. Marcus S. Fisher, Software Verification and Validation: An Engineering and Scientific Approach, Springer, 2007.

Course No: CSE 6113
Course Title: Advanced Operating Systems
Credit: 3.00

Course Content:

Theory: OS structures: SPIN, Exokernel, Microkernel and L3 Microkernel approach; Virtualization of Memory, CPU and Devices; **Process and Thread Management**: Advanced scheduling algorithms, process synchronization and communication mechanisms, lightweight processes and threading models. **Memory Management**: Virtual memory concepts, advanced memory allocation algorithms, memory protection mechanisms, and memory hierarchy optimization. **File Systems**: Distributed file systems, network file systems, journaling file systems, and advanced file system optimizations. Security and Protection: Access control models, authentication mechanisms, secure bootstrapping, and intrusion detection/prevention systems; **Parallel Systems**: Synchronization, communication, scheduling, lightweight RPC, Shared memory multiprocessor OS; **Distributed Systems**: Lamport clock, latency limits, Active networks, distributed shared memory, distributed file system; Failure and recovery: recoverable virtual memory, RioVista, Quicksilver; **Internet computing**: Giant internet services, MapReduce, Content delivery networks; **Security**: principles of information security, security in Andrew.

Empirical Study: Spring Operating System, Java RMI, Enterprise Java Beans.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of an operating system
CLO2	**Relate** the distributed operating systems
CLO3	**utilize** the system files
CLO4	**Apply** the security principles
CLO5	**Discover** different operating systems

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Advanced Operating Systems, Graduate course, Georgia Tech College of Computing, K. Ramachandran, C. Brubaker.
2. Abraham Silberschatz, and Peter Baer Galvin. Operating System Concepts. John Wiley & Sons, Inc.
3. Andrew S. Tanenbaum, Albert S. Woodhull, Operating Systems: Design and Implementation, Third Edition, Prentice Hall, 2006.
4. Official Ubuntu Documentation, https://help.ubuntu.com/

Course No: CSE 6115
Course Title: Distributed Computing
Credit: 3.00
Course Content:

Theory: Introduction to distributed computing models; Clock synchronization; Message Ordering and Group Communication; Termination Detection Algorithms; Reasoning with Knowledge; Distributed Mutual Exclusion Algorithms; Deadlock Detection Algorithms; Global Predicate Detection; Distributed Shared Memory; Checkpointing and Rollback Recovery; Consensus and Agreement; Failure Detectors; Distributed file servers; Distributed programming environments: Communication primitives, selected case studies.

Empirical Study: In this course, an instructor may provide the assignments where a student will participate in the design, assembling, configuring, and benchmarking a real cluster. The students would be exposed to practical issues in a real cluster design, such as hardware tradeoffs, different operating systems, local and distributed storage, networking, virtualization, and grid/cloud middleware. The students will work in teams

to build workstations/servers from scratch. The software stack will include Linux, XEN, Globus, Condor, OpenStack, NFS, PVFS, MPI, Swift, and Hadoop.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the distributed computing models
CLO2	**Compare** the deadlock detection algorithms
CLO3	**Discover** the distributed shared memory concept
CLO4	**Apply** Checkpointing and Rollback Recovery
CLO5	**Design** a distributed computer cluster

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Sukumar. Ghosh, Distributed systems: an algorithmic approach. Chapman and Hall/CRC, 2006.
2. Ajay D Kshemkalyani,. and Mukesh Singhal. Distributed computing: principles, algorithms, and systems. Cambridge University Press, 2011.
3. Gerard. Tel, Introduction to distributed algorithms. Cambridge university press, 2000. Distributed Algorithms, Nancy A. Lynch.
4. Hagit Attiya, and Jennifer Welch. Distributed computing: fundamentals, simulations, and advanced topics. Vol. 19. John Wiley & Sons, 2004.
5. Elements of Distributed Computing, Vijay K. Garg.
6. George F. Coulouris, Jean Dollimore, and Tim Kindberg. Distributed systems: concepts and design. pearson education, 2005.

Course No: CSE 6117
Course Title: Cloud Computing
Credit: 3.00
Prerequisite: Computer Networks*

Course Content:

Theory: Cloud Computing Overview, Create and deploy commercial multi-tier applications onto multiple (public/hybrid) cloud platforms. Plan and architect highly-scalable computing/data analytics solutions for business and scientific needs. Design pattern-based application code to run efficiently in a cloud environment. **Cloud Virtualization**: Resource Virtualization, Virtual Machines, Virtual Networks, **Web Services**: Simple Object Access Protocol (SOAP), Web Services Description Language (WSDL), Universal Description, Discovery and Integration, Representational State Transfer (REST), Integrated Applications as Web Service Workflows, **Microservices and Containers**: Web Server Containers, Containers from Scratch, Docker, Kubernetes. Load Balancing Types of Load Balancing, Selected Algorithms for Load Balancing, Load Balancing for Virtual Clusters, Google's Borg, and Omega, VM Migration. Evaluate security strategies associated with cloud computing and apply them to ensure the technical sustainability of an organization. Migrate from traditional ICT environment to a cloud-based platform. Manage the process of running an IT department as a cloud-enabled business unit.

Empirical Study: (Instructor may choose among the options)

- Install VirtualBox/VMware Workstation with Linux or windows OS.
- Install a programming environment, i.e., c/c++/python on the virtual machine and execute Programs
- Use GAE launcher to launch the web applications
- Simulate a cloud scenario using CloudSim or any other suitable simulator to run scheduling algorithm
- Find a procedure to transfer the files from one virtual machine to another virtual machine.
- Install Hadoop single node cluster and run simple applications like wordcount
- Any emerging technology can be chosen by the instructor (open).

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of cloud computing
CLO2	**Compare** the cloud base web services
CLO3	**Develop** highly-scalable computing solutions for business and scientific needs
CLO4	**Develop** RESTful applications
CLO5	**Create** virtualization technologies

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√		√					√				
CLO3										√		
CLO4											√	
CLO5												

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Anthony T. Velte, Toby J. Velte, and Robert Elsenpeter. "Cloud Computing: A Practical Approach." ISSN 2278 (2019): 0181.
2. Judith Hurwitz, Robin Bloor, Marcia Kaufman, and Fern Halper. "Cloud Computing." (2012).
3. Krutz, Ronald L., and Russell Dean Vines. Cloud security: A comprehensive guide to secure cloud computing. Wiley Publishing, 2010.
4. Marinescu, Dan C. Cloud computing: theory and practice. Morgan Kaufmann, 2017.

Course No: CSE 6119
Course Title: Courses of Current Interest/Special Topics Related to Computer System
Credit: 3.00

Any expert proposed by the department and approved by syllabus committee will conduct this course. A subtitle and content shall be determined and approved by the same committee. In the transcript of the students the subtitle will follow the main title (Example: M*CSE 64xx Special Topic –I: Big Data*).

CSE 6121 Research Methodology (3 Credits)
This course provides a forum for students to discuss and generate research ideas on issues related to a variety of applied engineering research. Students conduct an in-depth study of a research topic of their choice, discuss issues with experts in the field of research, work in discussion groups, research methodology and problem solve on selected issues. In the research seminar, the students are given an opportunity to integrate their knowledge, skills and practical experience gained in the program.

Outcome
Upon successful completion of this course, the student will have reliably demonstrated the ability to: 1. co-ordinate and participate in a seminar(s) on current research trends 2. successfully implement an in-depth research seminar utilizing field experts and collegial discussions/input. 3. fluent in writing a formal description of research design and research analysis, data collection methods for quantitative studies. 5. Reliability and validity of measures of quantitative data analysis techniques. Finally, learn analysis of analytical results from quantitative studies.

Reference

1. Writing Successful Science Proposals by Andrew J. Friedland, Carol L. Folt, Publisher: Yale University Press;
2. 2 edition (June 9, 2009) 2. The Myths of Innovation (Hardcover) by Scott Berkun, Publisher: O'Reilly Media (August 30, 2010)
3. 3. Pedhazur, E. J. and Schmelkin, L. P. Measurement, Design and Analysis: An Integrated Appoach, Psychology Press, 2013

3.4 Course Details

Track II: Intelligent Computing and Data Science

Course No: CSE 6201
Course Title: Advanced Artificial Intelligence and Expert System
Credit: 3.00

Course Content:
Theory: Introduction to Artificial Intelligence, Problem Solving: Advanced search techniques in AI, Knowledge, reasoning and planning: Logic agents, First order logic, Inference in First-order logic, Classical planning, Knowledge representation, Uncertain knowledge and reasoning: Quantifying uncertainty, Probabilistic reasoning, Making simple and complex decisions, Learning: Learning from examples, knowledge in learning, learning probabilistic models, Reinforcement learning, Communicating, perceiving, and acting: Natural language processing, Natural language for communication, perception, robotics.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of artificial intelligence
CLO2	**Utilize** the first order logic
CLO3	**Determine** advanced searching algorithms
CLO4	**Evaluate** an intelligent decision-making agent
CLO5	**Estimation of** natural language processing system

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4					√							
CLO5						√						

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Stuart Russell, and Peter Norvig. Prentice Hall series in artificial intelligence. Englewood Cliffs, NJ: Prentice Hall, 1995.
2. Mueller, John Paul, and Luca Massaron. Artificial intelligence for dummies. John Wiley & Sons, 2018.
3. Artificial Intelligence and Expert Systems by I. Gupta (Author), G. Nagpal (Author), Publisher Mercury Learning and Information, April 14, 2020
4. Artificial Intelligence: A Beginner's Guide from the Past, in the Present, and Through the Future Paperback – February 8, 2024 by Jason Jessup (Author), publish by Amazon prime, 2024

Course No: CSE 6203
Course Title: Computer Vision
Credit: 3.00

Course Content:
Theory: Models of images and image formation (camera models, camera calibration, statistics of images, the geometry of image formation and visual scenes); Color image processing: color models and transformations, edge detection and segmentation in color images, color image compression; Digital image security; Image content feature extraction, representation, and image retrieval; Concept learning and object recognition. Low-level image processing and feature extraction: Features and visual cues of images and scenes, shape and motion estimation, object recognition; Image segmentation, clustering, multiple-image

processing, case studies. Advanced Image Analysis Techniques: Morphological image processing, texture analysis, scale-space techniques, wavelet transform, Fourier transform, principal component analysis (PCA), independent component analysis (ICA), sparse coding. Deep Learning for Image Processing: Convolutional neural networks (CNNs), recurrent neural networks (RNNs), generative adversarial networks (GANs), transfer learning, fine-tuning pre-trained models, image classification, object detection, semantic segmentation. Medical Image Processing: Image enhancement techniques, medical image registration, image segmentation for medical diagnosis, computer-aided diagnosis (CAD), medical image reconstruction, applications in radiology, pathology, and healthcare. Remote Sensing Image Processing: Satellite image processing, hyperspectral image analysis, image fusion, feature extraction for land cover classification, change detection, urban monitoring, environmental monitoring. 3D Image Processing: Depth sensing technologies, stereo vision, structure from motion (SfM), 3D reconstruction, point cloud processing, volumetric image analysis, applications in robotics, virtual reality, augmented reality, and 3D printing. Image Processing Applications: Biometrics, surveillance and security, autonomous vehicles, augmented reality, digital forensics, multimedia content analysis, cultural heritage preservation, industrial automation, entertainment, and gaming. Emerging Trends in Image Processing: Explainable AI for image analysis, quantum image processing, bio-inspired image processing, ethical considerations in image analysis, interdisciplinary applications of image processing, and future directions in the field.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of computer vision
CLO2	**Interpret** the color image processing
CLO3	**Analyze** color images and image features
CLO4	**Create** image processing system
CLO5	**Develop** image recognition and classification system

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3				√								
CLO4					√							
CLO5			√									

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Szeliski, Richard. Computer vision: algorithms and applications. Springer Science & Business Media, 2010.
2. Prince, Simon JD. Computer vision: models, learning, and inference. Cambridge University Press, 2012. Forsyth, David, and Jean Ponce. Computer vision: A modern approach. Prentice hall, 2011.
3. Hands-On Computer Vision with Detectron2: Develop object detection and segmentation models with a code and visualization approach by Van Vung Pham (Author), Publisher: Packt Publishing,2023

Course No: CSE 6205
Course Title: Machine Learning
Credit: 3.00

Course Content:

Theory: Introduction of Machine Learning: Supervised Learning, Unsupervised Learning. Linear Regression with One Variable: Model Representation, Cost Function - Intuition I, Cost Function - Intuition II, Gradient Descent, Gradient Descent Intuition, Gradient Descent For Linear Regression. Linear Algebra Review: Matrices and Vectors, Addition and Scalar Multiplication, Matrix Multiplication Properties, Inverse and Transpose, Linear Regression with Multiple Variables: Multiple Features, Gradient Descent for Multiple Variable, Gradient Descent in Practice I - Feature Scaling, Gradient Descent in Practice II - Learning Rate, Features and Polynomial Regression, Normal Equation, Noninevitability, Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost Function, Simplified Cost

Function and Gradient Descent, Advanced Optimization, Multiclass Classification: One-vs-all Regularization: The Problem of Overfitting, Cost Function, Regularized Linear Regression, Regularized Logistic Regression, Advice for Applying Machine Learning: Evaluating a Hypothesis, Model Selection and Train/Validation/Test Sets, Diagnosing Bias vs. Variance, Regularization and Bias/Variance, Learning Curves, Machine Learning System Design: Error Analysis, Error Metrics for Skewed Classes, Trading Off Precision and Recall, Data For Machine Learning, Support Vector Machines: Optimization Objective, Large Margin Intuition, Mathematics Behind Large Margin Classification, Kernels, Unsupervised Learning: Introduction, K-Means Algorithm, Optimization Objective, Random Initialization, Choosing the Number of Clusters, Dimensionality Reduction: Data Compression, Visualization, Principal Component Analysis (PCA) Problem Formulation, PCA Analysis Algorithm, Reconstruction from Compressed Representation, Choosing the Number of Principal Components, Advice for Applying PCA, Large Scale Machine Learning: Learning With Large Datasets, Stochastic Gradient Descent, Mini-Batch Gradient Descent, Stochastic Gradient Descent Convergence, Online Learning, Map Reduce and Data Parallelism.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the supervised and unsupervised learning
CLO2	**Summarize** the supervised and unsupervised models
CLO3	**Create** clustering and classification models
CLO4	**Analyze** data using machine learning models
CLO5	**Apply** machine learning algorithms on data to make a decision

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2				√								
CLO3					√							
CLO4	√											
CLO5						√						

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Aurélien Géron, Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. O'Reilly Media, 2019.
2. Andreas C. Müller, and Sarah Guido. Introduction to machine learning with Python: a guide for data scientists. " O'Reilly Media, Inc.", 2016.
3. Paluszek, Michael, and Stephanie Thomas. MATLAB machine learning. Apress, 2016. Pattern Recognition and Machine Learning- Book by Christopher Bishop

Course No: CSE 6207
Course Title: Deep Learning
Credit: 3.00

Course Content:

Theory: Neural Networks Basics: Neural Networks and Deep Learning Overview, Neural Network Representation, Computing a Neural Network's Output, Vectorizing across multiple examples, Explanation for Vectorized Implementation, Activation functions, nonlinear activation functions, Derivatives of activation functions, Deep Neural Networks: Deep L-layer neural network: Forward Propagation in a Deep Network, matrix dimensions, deep representations, Building blocks of deep neural networks, Forward and Backward Propagation, Parameters vs Hyperparameters, Practical aspects of Deep Learning: Train / Dev / Test sets, Regularization, overfitting, Dropout Regularization, Normalizing inputs, Optimization algorithms: Mini-batch gradient descent, Understanding mini-batch gradient descent, Exponentially weighted averages, Understanding exponentially weighted averages, Bias correction in the exponentially weighted average, Gradient descent with momentum, RMSprop, Adam optimization algorithm, Learning rate decay, The problem of local optima. Hyperparameter tuning, Batch Normalization and Programming Frameworks: Tuning process, Using an appropriate scale to pick hyperparameters, Foundations of Convolutional Neural Networks: Computer Vision, Edge Detection, Padding, Stride Convolutions, Convolutions Over Volume, One Layer of a Convolutional Network, Simple Convolutional Network Example, Pooling Layers, CNN Example, Necessity of Convolutions, Deep convolutional models: case studies: Classic Networks, ResNet, Networks in Networks and 1x1 Convolutions, Inception Network Motivation, Inception Network, Transfer Learning, Data Augmentation, Recurrent Neural Networks:

Sequence models, Notation, Recurrent Neural Network Model, Backpropagation through time, Different types of RNNs, Language model and sequence generation, Sampling novel sequences, Vanishing gradients with RNNs, Gated Recurrent Unit (GRU), Long Short Term Memory (LSTM), Bidirectional RNN, Deep RNNs, Natural Language Processing & Word Embeddings: Word Representation, Using word embeddings, Properties of word embeddings, Embedding matrix, Learning word embeddings, Word2Vec, Negative Sampling, GloVe word vectors, Sentiment Classification, Debiasing word embeddings. .

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of deep learning
CLO2	**Understand** the deep neural networks
CLO3	**Create** a deep L-layer neural network
CLO4	**Apply** deep neural networks in problem solving
CLO5	**Analyze** different types of neural networks

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4					√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. C. Aggarwal Charu, Neural Networks and Deep Learning: A Textbook. Spinger, 2018.
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.
3. Loy, James. Neural Network Projects with Python: The ultimate guide to using Python to explore the true power of neural networks through six projects. Packt Publishing Ltd, 2019.
4. Howard, Jeremy, and Sylvain Gugger. Deep Learning for Coders with fastai and PyTorch. O'Reilly Media, 2020.

Course No: CSE 6209
Course Title: Data Science
Credit: 3.00

Course Content:
Theory: Defining Data Science and What Data Scientists Do: What is Data Science?, Fundamentals of Data Science, Old problems, new problems, Data Science solutions, Data Science Topics and Algorithms, Cloud for Data Science, Data Science Topics: Foundations of Big Data, What is Hadoop?, How Big Data is Driving Digital Transformation, Neural Networks and Deep Learning, Applications of Machine Learning, Data Scientist's Toolkit: Languages of Data Science, Introduction to Python, Introduction to R Language, Introduction to SQL, Other Languages, Categories of Data Science Tools, Open Source Tools for Data Science, Commercial Tools for Data Science, Cloud-Based Tools for Data Science, Libraries for Data Science, Application Programming Interfaces (API), Data Sets - Powering Data Science, Sharing Enterprise Data - Data Asset eXchange, Machine Learning Model, The Model Asset Exchange, Open Source Tools: Overview of Git/GitHub, Git and GitHub via command line (Optional), Branching and merging via command line (Optional), Contributing to repositories via pull request (Optional), Getting Started with Jupyter Notebook, Getting Started with JupyterLab, Jupyter Architecture, RStudio IDE, Installing Packages and Loading Libraries in RStudio IDE, Plotting Within RStudio IDE, IBM Tools for Data Science: IBM Watson Studio, Watson Studio Introduction, Creating an Account on IBM Watson Studio, Jupyter Notebook in Watson Studio, Linking GitHub to Watson Studio, Other IBM Tools for Data Science, IBM Watson

Knowledge Catalog, Data Refinery, SPSS Modeler Flows in Watson Studio, IBM SPSS Modeler, SPSS Statistics, Model Deployment with Watson Machine Learning, Auto AI in Watson Studio, IBM Watson OpenScale, From Problem to Approach and From Requirements to Collection: Business Understanding, Analytic Approach, Data Requirements, Data Collection, From Understanding to Preparation and From Modeling to Evaluation: Data Preparation, Modeling - Concepts, Modelling - Case Study, Evaluation, Working with Data in Python: Reading Files with Open, Writing Files with Open, Loading Data with Pandas, Pandas: Working with and Saving Data, One Dimensional Numpy, Two Dimensional Numpy, Simple APIs.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of data science
CLO2	**Build** the cloud system for data science
CLO3	**Analyze** big enterprise big data
CLO4	**Apply** data processing tools
CLO5	**Develop** data processing and visualization tools

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3				√								
CLO4					√							
CLO5			√									

Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Grus, Joel. Data science from scratch: first principles with python. O'Reilly Media, 2019.
2. Jake Vander Plas, Python data science handbook: Essential tools for working with data. " O'Reilly Media, Inc.", 2016.
3. Hadley Wickham, and Garrett Grolemund. R for data science: import, tidy, transform, visualize, and model data. " O'Reilly Media, Inc.", 2016.
4. Wendy L. Martinez, Angel R. Martinez, and Jeffrey L. Solka. Exploratory data analysis with MATLAB®. Chapman and Hall/CRC, 2017.

Course No: CSE 6211
Course Title: Big Data
Credit: 3.00

Course Content:
Theory: Introduction to Big Data: characteristics of Big Data and dimensions of scalability; Data Science: getting value out of Big Data, foundations for Big Data systems and programming, getting started with Hadoop; Big Data Modelling and Management Systems: Big Data modeling, Big Data management, designing a Big Data management system; Big Data Integration and Processing: retrieving Big Data, Big Data integration, processing Big Data, Big Data analytics using Spark; Machine Learning with Big Data: introduction to machine learning with Big Data, data exploration, classification, evaluation of machine learning models, regression, cluster analysis, and association analysis; Graph Analytics for Big Data: Introduction to graphs, graph Analytics, graph analytics techniques, computing platforms for graph analytics.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Define** the fundamentals of big data
CLO2	**Understand** big data modeling
CLO3	**Analyze** enterprise big data
CLO4	**Apply** big data processing tools such as Hadoop
CLO5	**Formulate** data processing and visualization tools

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3				√								
CLO4					√							
CLO5			√									

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. James Warren, and Nathan Marz. Big Data: Principles and best practices of scalable realtime data systems. Simon and Schuster, 2015.
2. Srini. Penchikala, Big data processing with apache spark. Lulu. com, 2018.
3. Andreas Meier, and Michael Kaufmann. SQL & NoSQL databases. Springer Fachmedien Wiesbaden, 2019.

Course No: CSE 6213
Course Title: Natural Language Processing (NLP)
Credit: 3.00

Course Content:
Introduction: NLP tasks in syntax, semantics, and pragmatics; applications such as information extraction, question answering, and machine translation; the problem of ambiguity; the role of machine learning; N-gram Language Models: The role of language models; Simple N-gram models; Estimating parameters and smoothing; Evaluating language models; Part Of Speech Tagging and Sequence Labeling: Lexical syntax; Hidden Markov Models (Forward and Viterbi algorithms and EM training); Basic Neural Networks: perceptron; backpropagation; LSTM Recurrent Neural Networks: Understanding; Long and Short term memory; Syntactic parsing: Grammar formalisms and treebanks; Efficient parsing for context-free grammars (CFGs); Statistical parsing and probabilistic CFGs (PCFGs); Lexicalized PCFGs; Neural shift-reduce dependency parsing; Semantic Analysis: Lexical semantics and word-sense disambiguation; Compositional semantics; Semantic Role Labeling and Semantic Parsing; Information Extraction (IE): Named entity recognition and relation extraction; IE using sequence labeling; Machine Translation (MT): Basic issues in MT; Statistical translation; word alignment; phrase-based translation; synchronous grammars.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of natural language processing
CLO2	**Simplify** NLP models
CLO3	**Apply** models for natural language processing
CLO4	**Determine** natural language processing tools
CLO5	**Analyze** NLP tools and techniques

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4					√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Vajjala, Sowmya, Bodhisattwa Majumder, Anuj Gupta, and Harshit Surana. Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems. O'Reilly Media, 2020.
2. Mishra, Brojo Kishore, and Raghvendra Kumar, eds. Natural Language Processing in Artificial Intelligence. CRC Press, 2020.
3. Bird, Steven, Ewan Klein, and Edward Loper. Natural language processing with Python: analyzing text with the natural language toolkit. " O'Reilly Media, Inc.", 2009

Course No: CSE 6215
Course Title: Business Intelligence
Credit: 3.00

Course Content:
Theory: Introduction to Business Intelligence; Business Intelligence Data Overview; Big Data in Business Intelligence; Data Collection & Quality; Business Intelligence Data Organization; Data Warehousing for Business Intelligence; Data Mining for Business Intelligence; Data Modeling for Business Intelligence; Data Analysis & Applications; Descriptive & Predictive Analytics; Web Analytics for Business Intelligence; Data Displays in Business Intelligence; Data Challenges in Business Intelligence; Business Intelligence Tools and Technologies; Real-time Business Intelligence; Cloud Computing in Business Intelligence; Mobile Business Intelligence; Social Media Analytics; Text Mining and Sentiment Analysis; Geographic Information Systems (GIS) in Business Intelligence; Customer Relationship Management (CRM)

Analytics; Fraud Detection and Prevention; Supply Chain Analytics; Financial Analytics; Healthcare Analytics; Retail Analytics; Marketing Analytics; Operational Analytics; Business Intelligence Governance and Security; Ethical Considerations in Business Intelligence; Business Intelligence Strategy and Implementation; Business Intelligence Case Studies and Best Practices.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of Business Intelligence
CLO2	**Choose** big data modeling in Business Intelligence
CLO3	**Analyze** enterprise Data Organization
CLO4	**Apply** Web Analytics for Business Intelligence
CLO5	**Compile** data processing model for Business Intelligence

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3				√		√						
CLO4												
CLO5					√							

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Provost, F., & Fawcett, T. (2013). Data Science for Business: What you need to know about data mining and data-analytic thinking. " O'Reilly Media, Inc.".
2. Competing on Analytics: The New Science of Winning- Book by Jeanne G. Harris and Thomas H. Davenport
3. Rick. Sherman, Business intelligence guidebook: From data integration to analytics. Newnes, 2014.
4. Bert. Brijs, Business analysis for business intelligence. CRC Press, 2016.

Course No: CSE 6217
Course Title: Robotics
Credit: 3.00

Course Content:
Theory: Introduction to robotics, geometry, kinematics, dynamics, Control systems, Configuration Space: Degrees of freedom, topology, parameterization, task space, and workspace, Rigid-Body Motions: Rotation matrices, exponential coordinates, homogeneous transformation matrices, screws, twists, and wrenches, Forward Kinematics: The product of exponentials (PoE) formula, the Denavit-Hartenberg convention, Velocity Kinematics and Statics: Jacobian, statics of open chains, singularity analysis, and manipulability, Inverse Kinematics: Analytic and numerical inverse kinematics, Dynamics of Open Chains: Forward and inverse dynamics, Euler-Lagrange and recursive Newton-Euler formulations, Trajectory Generation: Path, trajectory, and time-scaling, Robot Control: Motion and force control.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of robotics and control system
CLO2	**Determine the** configuration space and motions
CLO3	**Apply** algorithms to control robots
CLO4	**Develop** and control robots
CLO5	**Evaluate** performance of robots

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3					√							
CLO4						√						
CLO5				√								

Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. C. Frank, Modern Robotics-Mechanics, Planning, and Control. Cambridge University Press, 2017.
2. John J. Craig, Introduction to robotics: mechanics and control, 3/E. Pearson Education India, 2009.
3. Peter I. Corke, and Oussama Khatib. Robotics, vision and control: fundamental algorithms in MATLAB. Vol. 73. Berlin: Springer, 2011.
4. Cicolani, Jeff, and Jeff Cicolani. Beginning Robotics with Raspberry Pi and Arduino. Apress, 2018.
5. Siciliano Bruno, Sciavicco Lorenzo, Villani Luigi, and Oriolo Giuseppe. "Robotics: modelling, planning and control." (2010).

Course No: CSE 6219
Course Title: Bioinformatics
Credit: 3.00

Course Content:
Theory: Introduction; Molecular biology basics: DNA, RNA, genes, and proteins; Restriction mapping algorithm; Motif in DNA sequences, motif finding algorithms; Genome rearrangements, sorting by reversals and breakpoints; DNA sequence alignments; Gene prediction; Space-efficient sequence alignments, sub-quadratic alignment; DNA sequencing, genome sequencing, protein sequencing, spectrum graphs; Combinatorial pattern matching: Exact pattern matching, heuristic similarity search algorithms, approximate string matching, BLAST, FASTA; Clustering: Microarrays, hierarchical clustering, K-means clustering, corrupted cliques problem, CAST clustering algorithm; Evolutionary trees.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals bioinformatics
CLO2	**Explore** the knowledge of DNA, RNA, proteins and genomes
CLO3	**Criticize** different bioinformatic algorithms
CLO4	**Develop** algorithms for visualization and 2D/3D representation of DNA, RNA, and Proteins
CLO5	**Analyze** DNA, RNA, proteins and genes using algorithms

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3					√							
CLO4						√						
CLO5				√								

Mapping of Course Learning Outcomes (CLOs) with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Compeau, Phillip, and Pavel Pevzner. Bioinformatics algorithms: an active learning approach. Vol. 1. La Jolla, California: Active Learning Publishers, 2015.
2. Pevsner, Jonathan. Bioinformatics and functional genomics. John Wiley & Sons, 2015.
3. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools by Vince Buffalo, Aug 18, 2015

Course No: CSE 6221
Course Title: Human Computer Interaction
Credit: 3.0
Course Content:
History and Foundations of HCI; Research Frameworks in HCI; Modeling Social and Emotional Processes; Computer-Mediated Communication; Social and Embodied Interfaces I; Social and Embodied Interfaces II; Computer-Supported Collaborative Work; Speech Interfaces; Games; Crowdsourcing; Information Visualization; Prototyping and the Iterative Design Cycle; Interface Design and Methods of Evaluation; Ubiquitous Computing; Assistive and Accessible Interfaces; Future of HCI; User Experience Design Principles; Human-Centered Design Methods; Ethical Considerations in HCI; Interaction Design Patterns; Design Thinking Approaches; Cognitive Load and Mental Models; Feedback and Affordance in Interfaces; Mobile Interaction Design; Virtual Reality and Immersive Interfaces; Affective Computing; Human-Robot Interaction; Cross-Cultural Design; Designing for Special Populations; Wearable Technology Interfaces; Designing for Sustainability; Evaluating User Experience Metrics; HCI in Healthcare and Well-being; Designing for Privacy and Security; HCI in the Internet of Things (IoT); Tangible User Interfaces; Designing for Smart Environments; Natural User Interfaces; Accessibility Guidelines and Standards; Usability Testing Techniques; User Interface Animation; Emotion Recognition Systems; Collaborative Virtual Environments; Gesture-Based Interaction; Biofeedback Interfaces; Persuasive Technology; Designing for Mixed Reality Experiences; Emotional Design Principles; Designing for Attention Management; Visual Analytics; Adaptive User Interfaces; Human-AI Interaction; Generative Design; Emotional Intelligence in Interfaces; User Interface Personalization; Sociotechnical Systems Design.

Assessment Strategy:

1. Exams: Multiple Choice and Short Answer Questions, Mid Term and Final Exam
2. Projects: Implementation and Research Projects
3. Presentations: Presentations and Problem-solving Sessions
4. Practical Demonstrations: Lab Exercises and Demonstrations of AI Systems
5. Continuous Assessment: Quizzes and Class Participation

Course Learning Outcomes (CLOs): At the end of the course, student will be able to-

CLOs	Statements
CLO1	**Describe** the fundamentals of human computer interaction
CLO2	**Illustrate** computer-mediated communication
CLO3	**Apply** computers for collaborative work
CLO4	**Develop** interfaces for human computer interaction
CLO5	**Analyze** performance of computer interfaces

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2										√		
CLO3					√							
CLO4						√						
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Preece Jennifer, Rogers Yvonne, and Sharp Helen. "Interaction design: beyond human computer interaction." NY: Wiley (2002).
2. Dix, Alan, Janet Finlay, Gregory D. Abowd, and Russell Beale. Human-computer interaction. Pearson Education, 2003.
3. Shneiderman, Ben, and Catherine Plaisant. Designing the user interface: Strategies for effective human-computer interaction. Pearson Education India, 2010.
4. Human-Computer Interaction: An Empirical Research Perspective- Book by I. Scott MacKenzie

Course No: CSE 6223
Course Title: Courses of Current Interest/Special Topics Related to Intelligent Computing and Data Science
Credit: 3.00

Any expert proposed by the department and approved by syllabus committee will conduct this course. A subtitle and content shall be determined and approved by the same committee. In the transcript of the students the subtitle will follow the main title (Example: M*CSE 6213 Special Topic –I: Big Data*).

3.5 Course Details

Track III: Network and Security

Course No: CSE 6301
Course Title: Cryptography
Credit: 3.00

Prerequisite: (Discrete Mathematics, Data Structure, Algorithm, Computer Networks) *

Course Content

Theory: Classical Cryptography: Introduction to simple cryptosystems, Cryptanalysis, Mathematics of Cryptography: Integer and Modular Arithmetic, Matrices, Linear Congruence, Shannon's Theory: Perfect secrecy, Entropy, Product cryptosystems, Data Encryption Standard: Description of DES, Differential cryptanalysis, Mathematics of Asymmetric-Key Cryptography, RSA System and Factoring: Public-key cryptography, RSA cryptosystem, Attacks on RSA, Factoring algorithms, Other Public-key Cryptosystems: ElGamal cryptosystem and discrete logs, Merkle-Hellman Knapsack System, Signature Schemes: Digital signature standard, Fail-stop signatures, Hash Functions: Signatures and Hash functions, Collision-free Hash functions, Birthday attack, Key Distribution and Key Agreement: Key redistribution, Kerboros, Diffie-Hellman key exchange, Identification Schemes: Schnorr identification scheme, Okamoto identification schemes, Authentication Codes: Computing deception probabilities, Combinatorial bounds, Entropy bounds, Secret Sharing Schemes: Shamir threshold scheme, Access structure and general secret sharing, Pseudo-random Number Generation: Indistinguishable probability distribution, probabilistic encryption, Zero-knowledge proofs: Interactive proof systems, computational Zero-knowledge proofs.

Empirical Study: (Instructor may choose among the options)
· Any suitable programming languages, i.e., c/c++, python, MATLAB to implement the symmetric and asymmetric key encryption/decryption process, digital signature, hash calculation, key generation etc.
· Any emerging cryptography idea can be chosen by the instructor (open)
This course shall include programming projects to implement cryptography ideas.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the basics of cryptosystems, Cryptanalysis
CLO2	**Design** the Mathematical models of Cryptography
CLO3	**Make** a suitable model to test suites to ensure Data Encryption Standard
CLO4	**Implement** Key Distribution and Identification Schemes
CLO5	**Apply** Indistinguishable probability distribution of encryption

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2			√									
CLO3			√									
CLO4					√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Katz, Jonathan, and Yehuda Lindell. Introduction to modern cryptography. CRC press, 2020.
2. Behrouz A. Forouzan, and Debdeep Mukhopadhyay. Cryptography and network security. New York, NY: Mc Graw Hill Education (India) Private Limited, 2015.
3. Ziliak, Ellen. "The Mathematics of Secrets: Cryptography from Caesar Ciphers to Digital Encryption." Math Horizons 25, no. 1 (2017).
4. Cryptography and Network Security Principles and Practice, Sixth Edition, William Stalllings

Course No: CSE 6303
Course Title: Network Security
Credit: 3.00

Course Content:

Theory: Security at the Application Layer: PGP and S/MIME, Security at the Transport Layer: SSL and TLS: SSL Architecture, Transport Layer Security, Security at the Network Layer: IPSec, Security Association, Security Policy, Internet Key Exchange (IKE), Distributed denial of service (DDOS) attacks, Security for communication protocols, Security for operating systems and mobile programs, Security for electronic commerce, passwords and offline attacks, Network Security Applications: Authentication, E-mail, IP and web, System Security: Intruders, Malicious software and firewalls, PKI smart cards, Secure multipurpose internet mail extensions, Viruses and spy ware, Security models, Wireless security, Sandboxing, Router security strategies and network security assessment.

Empirical Study: (Instructor may choose among the options)

- Building a Virtual Hardware and Software Test Platform, i.e., VMware, Virtual Box and Linux
- Analyzing Network Traffic by Wireshark packet analyzer
- Penetration testing, vulnerability analysis, and exploitation tools.
- Any emerging cryptography idea can be chosen by the instructor (open)

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Explain** the basics of Security at the different Layers
CLO2	**Design** the Security Policy and communication protocols
CLO3	**Implement** Security protocols for operating systems and mobile programs
CLO4	**Combine** Network Security and Applications
CLO5	**Apply** Wireless security, Router and network security strategies

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2			√									
CLO3				√								
CLO4							√					
CLO5			√			√						

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Forouzan, Behrouz A., and Debdeep Mukhopadhyay. Cryptography and network security. New York, NY: Mc Graw Hill Education (India) Private Limited, 2015.
2. William. Stallings, "Cryptography and Network Security: Principles and Practice."
3. Network Security Essentials, Prentice-Hall by William Stallings, 2000.

Course No: CSE 6305
Course Title: Information System Security Management
Credit: 3.00

Course Content:

Theory: Introduction to Information Security and Scientific Management: Information Sensitivity Classification, Information Security Governance, The Computing Environment, Security of Various Components in the Computing Environment, Security Goals versus Business Goals, Introduction to Management Concepts: Traditional Management Skills and Security Literacy, Strategic Management Concepts, Security Management Activities, Security Management versus Functional Management, The Information Security Life Cycle (SLC): Security Planning in the SLC, Security Analysis, Security Design, Security Plan (SP): SP Development Guidelines, Risk Management in Security Planning, Certification and Accreditation Process, SP Analysis, SP Methodology, Security Policy: Security Policy, Standards, and

Guidelines, Security Policy Methodologies, The Corporate Vital Defense Strategy, Security Policy Based on Computing Boundaries, Business Continuity Planning (BCP):Business Disruptions, Disaster Recovery, Responding to Business Disruptions, Developing a BCP, Security Risk Management: The Risk Management Life Cycle, The Preparation Effort for Risk Management, A Sustainable Security Culture, Information Needed to Manage Risks, Factors Affecting Security Risk, Active Security Assessment Information Security Management and Security Awareness education and training, Overview of Security Planning, and Incident Management

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the basics of Information Security and Scientific Management
CLO2	**Design** the Security Management Methodologies
CLO3	**Implement** the Information Security Life Cycle (SLC)
CLO4	**Assess** Certification and Accreditation Process
CLO5	**Apply** Security Awareness education and training and Incident Management

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4			√									
CLO5					√							

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Bel G. Raggad, Information security management: Concepts and practice. CRC Press, 2010.
2. Seymour Goodman, Detmar W. Straub, and Richard Baskerville. Information security:

policy, processes, and practices. Routledge, 2016.
3. Michael Workman, Information Security Management, 2nd Edition,2021 Publisher(s): Jones & Bartlett Learning
4. Andy Taylor, David Alexander, Amanda Finch, David Sutton, "Information Security Management Principles, 3rd Edition, 2020. Publisher(s): BCS, The Chartered Institute for IT.

Course No: CSE 6307
Course Title: Computer Communications and Networks
Credit: 3.00

Theory: Computer Communication and Networking for Today's Enterprise, Protocol Architecture, TCP/IP, and Internet Based Applications, Analog Data, Analog Signals, Forward Error-Correcting Codes, Wireless Transmission Techniques: MIMO Antennas, OFDM, OFDMA, and SC-FDMA, Spread Spectrum, Direct Sequence Spread Spectrum, Code Division Multiple Access, Wireless Networks: Fixed Broadband Wireless Access, WiMAX/IEEE 802.16, Bluetooth, Routing: Routing in Packet-Switching Networks, Internet Routing Protocols, Least-Cost Algorithms, Congestion Control: Effects of Congestion, Traffic Management, Congestion Control in Packet-Switching Networks, TCP Congestion Control, Datagram Congestion Control Protocol, Internetwork Operation: Multicasting, Software-Defined Networks, OpenFlow, Mobile IP, Internetwork Quality of Service: QOS Architectural Framework, Resource Reservation Protocol, Service Level Agreements, IP Performance Metrics, Multiprotocol Label Switching (MPLS): MPLS Operation, FECs, LSPs, and Labels, Label Distribution, Traffic Engineering, Virtual Private Networks (VPN), Internet Multimedia Support: Real-Time Traffic, Voice Over IP, Session Initiation Protocol, Real-Time Transport Protocol (RTP), RTCP, RTSP,Empirical Study: (Instructor may choose among the options)

- Packet tracer/NS3 simulator to simulate the different networking topologies
- Any emerging technology can be chosen by the instructor (open).

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Analyze** the basics of Communication and Networking
CLO2	**Design** the Protocol Architecture and Internet Based Applications
CLO3	**Implement the** Internet Routing Protocols, Least-Cost Algorithms for Congestion Control
CLO4	**Evaluate** Quality of Service: QOS of Internetwork Architectural Framework
CLO5	**Improve** Multiprotocol Label Switching (MPLS): MPLS Operation

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2			√									
CLO3			√									
CLO4					√							
CLO5										√		

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Stallings, William. Data and computer communications. Pearson Education India, 2007.
2. Data Communications and Networking, Behrouz A. Forouzan
3. Computer Networks, Andrew S. Tanenbaum
4. Doug Lowe, "Networking All-in-One for Dummies",8th edition, 2021
5. James Kurose, Keith Ross, "Computer Networking, - A top-down approach" Global Edition, 8th edition, 2021

Course No: CSE 6309
Course Title: Advanced Wireless and Mobile Networks
Credit: 3.00

Course Content:

Theory: Overview of wireless networking technologies. Advanced solutions for wireless and mobile networks (5G, 4G, HSPA+, 3G LTE, IMT-Advanced, satellite UMTS, Mobile WiMAX, IEEE 802.20, IEEE 802.11n). The Electromagnetic Spectrum; Spread Spectrum; Frequency Reuse; Radio Propagation Mechanisms, Signals, Antennas; Characteristics of Wireless Channels; Modulation Techniques and Multiple Access Techniques for Wireless Systems. Overview of DVB technologies. Tele traffic engineering of wireless and mobile networks. Modeling and dimensioning of wireless and mobile networks. Network planning. Calculation of system capacity and optimal coverage. Performance analysis of radio resource management algorithms in wireless and mobile networks (power control, handover control, access control, load control). Connection management (mobility, session). Analysis of specific scenarios. Integration of navigation and communications systems. Localization of users. Location based services. Situation aware services. Advanced solutions for service discovery in wireless and mobile networks. Context aware services. Sensor networks. Advanced algorithms for control and management in sensor networks. Personal area networks (WPAN, WBAN). Medium independent handover. Standardization (IEEE 802.21). Cooperative networks. Social, operational and communication aspects. Implementation. Cognitive networks. Architectures and protocols. Fundamental limits. Spectral awareness. Standardization and new standards (e.g. IEEE 802.22, IEEE 802.11p, -af, -ae). Development towards 4G. Standardization activities (3GPP, ITU, ETSI, IEEE 802.x). Hybrid Routing Protocols; Routing Protocols with Efficient Flooding Mechanisms.

Empirical Study: (Instructor may choose among the options)

· Packet tracer/NS3/MATLAB simulator to simulate the different topologies of wireless and mobile network

· Any emerging technology can be chosen by the instructor (open).

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Classify** the basics of Communication and Networking
CLO2	**Design** the wireless and mobile networks.
CLO3	**Implement the** Advanced algorithms for control and management in sensor networks
CLO4	**Analysis** of specific navigation scenarios and communications systems.
CLO5	**Apply** Innovative network solutions.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√								√		
CLO3			√									
CLO4				√								
CLO5					√							

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Liljana Gavrilovska, and Ramjee Prasad. "Ad hoc networking towards seamless communications." (2006).
2. Martin. Sauter, Beyond 3G-Bringing networks, terminals and the web together: LTE, WiMAX, IMS, 4G Devices and the Mobile Web 2.0. John Wiley & Sons, 2011.
3. Frank HP Fitzek, and Marcos D. Katz, eds. Cognitive wireless networks: concepts, methodologies and visions inspiring the age of enlightenment of wireless communications. Springer Science & Business Media, 2007.
4. Introduction to Wireless& Mobile Systems, D. P. Agrawal and Qing-An Zeng, Cengage Learning, 4th Edition, 2014 (ISBN: 978-1-305-08713-2)
5. No fixed text books. Study materials, including some research papers on wireless networks will be provided by instructors.

Course No: CSE 6311

Course Title: Fiber Optic Communications System
Credit: 3.00

Course Content:

Theory: Introduction to fiber-optic communications (e.g. overview, fiber optic waveguides, and optical fiber characteristics: fiber dispersion, nonlinearity, and loss). **Optical transmitters**: LED, VCSEL and

DFB, LED characteristics (Planar LED, Dome LED, Surface emitter LEDs, Micro, RGB LED, Edge emitter LEDs, Super luminescent LEDs, quantum-dot LEDs -Laser Diode, APD, Basic concepts (The p–n junction, Spontaneous emission, Carrier recombination. **Optical receivers** (e.g., photodiodes, avalanche photodetectors) and receiver components performance. **Optical modulators**: electro-optic and electro-absorption, internal and external modulation, (Pulse Amplitude Modulation (PAM), Pulse Code Modulation (PCM)) coherent and incoherent detection. Higher-order modulation schemes: ODB, DPSK, DQPSK, Pol-Mod: QPSK, etc. **Optical amplifiers**: EDFA, Raman and semiconductor. Fiber optic system design and performance (**Radio over Fiber: -** Fiber wireless systems, intensity modulation/ direct detection (IM/DD) and Coherent detection system. Losses and gains, power budget calculations, optical electrical and cumulative SNRs). Dispersion management, Long-Haul and Metro DWDM fiber optic systems, Comparison of different types of fiber (SMF), (MMF), Analog fiber optic links, Plastic optical fiber links. **Optical Multiplexing:** Concept, Frequency Division Multiplexing, Analog Hierarchy, Wavelength Division Multiplexing (WDM), Code division multiplexing (CWDM), Deans division Multiplex (DWDM).

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Determine** the basics of fiber-optic communications.
CLO2	**Design** idea of optical transmitters, channels and receiver.
CLO3	**Implement the** Higher-order modulation schemes: ODB, DPSK, DQPSK, QPSK
CLO4	**Examine** the system design and performance (e.g. bit-error rate, signal-to-noise ratio).
CLO5	**Develop** fiber optic links.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4				√						√		
CLO5			√									

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Fiber-optic communication systems. (Wiley Series in Microwave and Optical Engineering) by Govind P. Agrawal, 5th Edition. John Wiley & Sons, 2021.
2. Lightwave Technology: Components and Devicesy, Govind P. Agrawal, Wiley-Interscience
3. Diode Lasers and Photonic Integrated Circuits 2nd Edition, by Larry A. Coldren (Author), Scott W. Corzine (Author), Milan L. Mashanovitch, Publisher Wiley.
4. Physics of Semiconductor Devices 4th Edition, by Simon M. Sze , Publisher Wiley
5. Optical Communications: Components and Systems 3rd ed. 2020 Edition by Martin Sibley, Springer, 2020

Course No: CSE 6313
Course Title: Data Management in Cloud
Credit: 3.00

Course Content:

Theory: Cloud Computing: Introduction- Systematic organization of data on cloud computing architectures; basic indexing techniques, including B-tree and hash-based indexing; fundamentals of query optimization, including access path selection and cardinality estimation; full and partial replication. Definition and characteristics, Service Models of Cloud, Business Models of Cloud, Cloud Computing Standards for data management, Cloud infrastructure (IaaS), Cloud platforms (PaaS), Cloud based software services (SaaS), Data storage strategy and governance, Virtualization Cloud scalability and operational efficiency, Securing data for transport, Scalability and Cloud Services- Large Scale Data Processing, Mobile cloud computing, Databases and Data Store, Data Archival, Big Data analytics on cloud, Scalable Computing Techniques, Next generation Cloud Computing/Emergent trend and practices of data management in cloud (e.g., Edge/Fog Computing, Cyber-Physical Cloud Computing Systems.).

Empirical Study: (Instructor may choose among the options.)

- Distributed File Systems (Hadoop Distributed File System (HDFS) with Ceph File System (CephFS))
- Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB)
- Introducing Amazon web service (AWS- EC2 and S3**)/**Google Cloud Platform (GCP)/Microsoft Azure
- OpenStack/Future Grid
- Twitter analytics web service for team projects.
- Any emerging practices chosen by the instructor (Open)

This course shall include practical projects by the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Construct** the basics of Cloud Computing.
CLO2	**Design** idea of Cloud Computing Standards for data management.
CLO3	**Implement the** Virtualization Cloud scalability and operational efficiency
CLO4	**Analysis** the Scalability and Cloud Services.
CLO5	**Test** Cloud Computing/Emergent and practices of data management.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4					√							
CLO5					√							

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. A. Srinivasan, Cloud Computing: A practical approach for learning and implementation. Pearson Education India, 2014.
2. Michael J. Kavis, Architecting the cloud: design decisions for cloud computing service models (SaaS, PaaS, and IaaS). John Wiley & Sons, 2014.
3. The Most Complete Guide to Amazon Web Services from Beginner to Advanced Level- Roul Alongi
4. Kevin Jackson, and Cody Bunch. OpenStack cloud computing cookbook. Vol. 42. Birmingham: Packt Publishing, 2012.
5. Microsoft Azure for Dummies- Timothy L. Warner

Course No: CSE 6315
Course Title: Blockchain Technology
Credit: 3.00

Course Content:

Theory: Introduction to Cryptography, Security (CIA- Confidentiality, Integrity, and Authenticity) and privacy properties, Hashing Functions and Applications, Public Key Encryption, Digital Signature Schemes, Tokenization, Overview of cryptocurrencies, Transactions, P2P Network, Overview of Consensus Protocols, Blockchain Ecosystem, Conventional Database vs. Blockchain, Blockchain Design Principles, Types of Blockchain (Private, Consortium, and Public), Consensus Algorithms (Proof of Work (PoW), Proof of Stake (PoS), Proof of Authority (PoA), any emerging strategy, etc.), Round Robin Mining, Multichain, Business model using Blockchain, Use case of Blockchain (Blockchain in Supply Chain, Blockchain in Manufacturing, Blockchain in Automobiles, Blockchain in Healthcare, Blockchain in Cyber security, Blockchain in Financial Industry)

Empirical Study: (Instructor may choose among the options.)

- Decentralized Application (Dapps)
- Ethereum- Ethereum Virtual Machine (EVM), Solidity for smart contracts, Smart Contracts writing, Web3, Truffle, Meta Mask, Integration with Ethereum Network (Installing Geth Client & Configuring Ethereum Nodes)
- Hyperledger Fabric- Overview of Docker and GitHub, Writing Chain Code, Integration with fabric network/ Building the first network
- Corda
- Any emerging practices can be chosen by the instructor (Open)

This course shall include practical projects on developing blockchain applications by the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Identify** the basics of Cryptography.
CLO2	**Design** idea of Consensus Protocols, Blockchain Ecosystem.
CLO3	**Implement** Blockchain Design Principles
CLO4	**Analysis** the Business model using Blockchain.
CLO5	**Justify the** Blockchain system in Cyber security and Financial Industry.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4			√									
CLO5					√					√		

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Jonathan Katz, and Yehuda Lindell. Introduction to modern cryptography. CRC press, 2020.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.
3. Blockchain White Paper- Satoshi Nakamoto
4. Ethereum Tutorial- https://ethereum.org/en/developers/
5. Hyperledger Fabric Tutorial- https://hyperledger-fabric.readthedocs.io/en/latest/test_network.html

Course No: CSE 6317
Course Title: Internet of Things (IoT)
Credit: 3.00
Prerequisite: (Digital Logic & System Design, Computer Networks) *

Course Content:

Overview of Embedded Systems, Components of Embedded Systems, Micro-controller Architecture and Properties, Overview of IoT, Brief History and evolution of IoT, key components of an IoT system, Trends in the Adoption of IoT, Roles of IoT in business strategy, Risks, Privacy, and Security, Cryptography in IoT, Cloud computing in IoT, Industrial IoT concepts, Arduino Programming basics, Sketch structure, Arduino Shields, GPIOs, Analog I/Os, Memory usage, Timers, Counters, Interrupts and its sources, Communication protocols I - UART, SPI, I2C, CAN, Interfacing IoT sensors and Actuators, Debug applications using Arduino IDE, Communication protocols II – Wired and Wireless communication, Ethernet Client Server Implementation, Smart sensors & actuators, wireless sensor networks, IoT and WiFi integrated Application, IoT and Bluetooth based Application, Mobile App and IoT integrated Application, Cloud Platform (DB) for IOT, IoT protocol stacks (Zigbee, 5G, NFC, MQTT, etc),

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Summarize** the basics of Components of Embedded Systems.
CLO2	**Design** idea of Micro-controller Architecture for IoT applications.
CLO3	**Implement the** Arduino Programming basics.
CLO4	**Analysis** the applications using Arduino IDE, Communication protocols.
CLO5	**Apply** Mobile App and IoT integrated Application.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4			√			√						
CLO5			√							√		

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Simon. Monk, Programming Arduino: getting started with sketches. McGraw-Hill Education, 2016.
2. John M. Hughes, Arduino: a technical reference: a handbook for technicians, engineers, and makers. " O'Reilly Media, Inc.", 2016.
3. Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud (Make: Projects) 3rd Edition, Kindle Edition, Publisher Make Community, LLC
4. Computer Peripherals- Barry Wilinson
5. Enterprise IoT: Strategies & Best Practices for Connected Products & Services 1st Edition by Dirk Slama, Publisher Oreilly & Associates Inc.

Course No: CSE 6319
Course Title: Ethical Hacking
Credit: 3.00

Course Content:

Theory: Change the way to view cyber security so adopt an offensive approach. The best way to beat a hacker is to be able to think like one! Wide range of subjects, including penetration testing, digital forensics, information security management, Malware analysis, port scanning, buffer overflows and password cracking. This course will help to pursue a successful and often lucrative career. Lectures are used to present the key concepts, while practical's increase understanding of the subject and allow to develop competence in technological and theoretical work. Taught using a problem-based learning approach. The taught course will be assessed using a combination of written coursework, presentations, and seminars, with a written dissertation at MSc level.

Empirical Study: (Instructor may choose among the options.)

· Installing Virtual Box (VB)/VMWare and Kali Linux and Other

- Operating Systems on it
- Practising Linux Terminal, Basic Commands
- Setting Up a Penetration Testing and Network Security Lab
- Setup Python Environment for Ethical Hacking
- Protect Anonymity on the Internet
- Build a Kali Web Server
- Dark Web and Tor
- Proxy Chains
- Virtual Private Network or VPN
- Any emerging practices can be chosen by the instructor (Open)

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the basics of Components of Embedded Systems.
CLO2	**Design** idea of Micro-controller Architecture for IoT applications.
CLO3	**Implement the** Arduino Programming basics.
CLO4	**Analysis** the applications using Arduino IDE, Communication protocols.
CLO5	**Build** Mobile App and IoT integrated Application.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2			√									
CLO3			√									√
CLO4					√							
CLO5					√					√		

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Sanjib Sinha, Sanjib Sinha, and Karkal. Beginning Ethical Hacking with Kali Linux. Apress, 2018.
2. Sanjib. Sinha, Beginning Ethical Hacking with Python. Apress, 2017.
3. Hacklog: Volume 1, Stefano Novelli
4. Learn Wireshark Confidently navigate the Wireshark interface and solve real-world networking problems, Lisa Bock
5. Singh, Glen D. Learn Kali Linux 2019: Perform Powerful Penetration Testing Using Kali Linux, Metasploit, Nessus, Nmap, and Wireshark. Packt Publishing Ltd, 2019.

Course No: CSE 6321
Course Title: Cybercrime and Digital Forensic
Credit: 3.00

Course Content:

Theory: Technology And Cybercrime, Law Enforcement, Privacy, And Security In Dealing With Cybercrime, Computer Hackers And Hacking: Defining computer hacking, Victims of hacking, hacker subculture, Hacking history, Legal frameworks to prosecute hacking, Enforcing and investigating hacker activity, Malware And Automated Computer Attacks: The basics of malware, Viruses, trojans, and worms, The global impact of malware, Hackers and malware writers, The market for malicious software, Legal challenges in dealing with malware, Coordination and management in addressing malware, Digital Piracy And Intellectual Property Theft: The subculture of piracy, law enforcement and industry response, Economic Crimes And Online Fraud: Fraud and computer-mediated communications, Identity theft, Scams, The problem of carding and stolen data markets, Identity theft and fraud laws, Cybercrime And Criminological Theories: Subcultural theories, Social learning theory and cybercrime, General theory of crime, Theories of cybercrime victimization, Evolution Of Digital Forensics: From computer forensics to digital forensics, Stages of digital forensic investigation, The role of digital evidence, Types of hardware, peripherals, and electronic evidence, Evidence integrity, Acquisition And Examination Of Forensic Evidence: Data preservation, Digital forensic imaging tools, Uncovering digital evidence, Data analysis, Data reduction and filtering, Reporting of findings, Legal Challenges In Digital Forensic: Constitutional issues in digital investigations, Federal Rules of Evidence, The Future Of Cybercrime, Terror, And Policy: Considering the future of cybercrime, New technologies Social movements, technology, and social change, Shifting enforcement strategies in the age of the Internet Considering the future of forensics, The challenge to policy makers globally.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the basics of Cybercrime and Digital Forensic.
CLO2	**Function of** hacker subculture and Legal frameworks to prosecute hacking.
CLO3	**Implement** Constitutional issues in digital investigations.
CLO4	**Analysis** the Stages of digital forensic investigation.
CLO5	**Justify** the new hardware, peripherals, and electronic evidence to integrity.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3					√							
CLO4					√							
CLO5			√									√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Cybercrime and Digital Forensics, Thomas J. Holt, Adam M. Bossler, and Kathryn C. Seigfried-Spellar
2. What Every Engineer Should Know About Cyber Security and Digital Forensics, Joanna F. DeFranco
3. The Best Damn Cybercrime and Digital Forensics Book Period, Jack Wiles, Anthony Reyes
4. Cybercrime and Digital Forensics: An Introduction, By Thomas J. Holt, Adam M. Bossler, 2022, published by Routledge
5. Digital Forensics and Cyber Crime,13th EAI International Conference, ICDF2C 2022, Proceedings book

Course No: CSE 6323
Course Title: Cyber Security and ICT law
Credit: 3.00
Prerequisite: None

Course Content:

Theory: Explain the relationship between law and information and communication technology (IT) within the areas of electronic communications, intellectual property, privacy/data protection and electronic commerce. Suggest ways in which IT could be applied in judicial processes and enforcement of law. Critically assess the challenges posed by IT to law, including assessment of the efficacy of law in the digital environment. Interpret and apply legal rules in development and enforcement of IT contracts and service level agreements. Analyze the legal and regulatory implications of adoption and use of IT. Develop mastery of the rules and discourse of IT law and suggest and assess alternative forms of regulation to traditional law. Demonstrate the ability to independently plan, design, execute, and report a scholarly research project.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Classify** the basics of the relationship between law and information and communication technology (IT).
CLO2	**Design** idea of IoT applications.
CLO3	**Implement the** data protection and electronic commerce strategies.
CLO4	**Analysis** the legal and regulatory implications of adoption and use of IT.
CLO5	**Ability** to independently plan, design, execute, and report a scholarly research project.

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√									
CLO4					√							
CLO5										√		√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Cyber-Security and Information Warfare, Nicholas J. Daras
2. Security And Law Legal and Ethical Aspects of Public Security, Cyber Security and Critical Infrastructure Security, Anton Vedder, Jessica Schroers,Charlotte Ducuing, Peggy Valcke

3.http://www.itu.int/ITU-D/cyb/cybersecurity/docs/Cybercrime%20legislation%20EV6.pdf

4.https://www.cirt.gov.bd/wp-content/uploads/2018/12/Digital-Security-Act-2018-English-version.pdf

5. Dr. Zulfiquar Ahmed, "A Text on Cyber Law in Bangladesh", Publisher: Hasan Law Books,2021

Course No: CSE 6325
Course Title: Courses of Current Interest/Special Topics Related to Network and Security
Credit: 3.00

Course Content:

Any expert proposed by the department and approved by syllabus committee will conduct this course. A subtitle and content shall be determined and approved by the same committee. In the transcript of the students the subtitle will follow the main title (Example: *CSE 6303 Special Topic –I: Network security*).

3.6 Course Details

Track IV: Software Engineering

Course No: CSE 6401
Course Title: Software design and Integration
Credit: 3.00
Prerequisite: (Structured Programming, Data structure, Algorithm) *

Course Content:

Theory: Analyzing, Designing, Implementing and Testing programs using Object Oriented Technologies, in order to produce maintainable, high-quality, software applications, Applying Software Engineering good practices, methods, notations and tools for the development of software applications inside a working team, Requirements elicitation for medium-size applications, Requirements representation and analysis using flow-oriented and scenario-oriented notations, Architectural high-level design of software applications, Structural and behavioural design of software applications, using the Object Oriented paradigm, Implementation of a medium-size software application using Java, working in a team, Design of test suites guaranteeing a certain level of confidence in the software quality, Good practices in Software Engineering, and testing tools like JUnit, Integration testing, system testing and acceptance testing.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Choose** and analyze software application programs using OOP technologies
CLO2	**Design** maintainable and high-quality software applications
CLO3	**Survey** test suites to ensure software quality
CLO4	**Implement** medium-sized software application and group projects
CLO5	**Utilize** software engineering good practices and methods in software development

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3			√						√			
CLO4			√									
CLO5							√					√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Software engineering a practitioner's approach, 7ªed. Roger Pressman. McGraw Hill Higher Education, 2010. INF/681.3.06/PRE. Available in Spanish.
2. Software engineering, 9ª ed. Addison Wesley. Ian Sommerville. INF/681.3.06/SOM. Available in Spanish.
3. Software requirements styles and techniques. Lauesen, Soren. AddisonWesley, 2002. INF/C6000/LAU.
4. Software Architecture in Practice (2nd Edition). Bass, Clements, Kazman. Addison-Wesley Professional, 2003. INF/C5220/BAS.
5. Software Architecture: Foundations, Theory, and Practice. R. N. Taylor, N. Medvidovic, E. M. Dashofy, E. M. Dashofy. Wiley, 2010. INF/681.3.06/TAY
6. Designing the User Interface Strategies for effective human-computer interaction. Shneiderman, Ben. Pearson Education, 2005. INF/C5610/SHN.

Course No: CSE 6403
Course Title: Software Project Management
Credit: 3.00
Prerequisite: None

Course Content:

Theory: Types of software projects, Software development life cycle models, RUP, Continuous improvement process & CMMi, Agile techniques, Designing Project Roadmap, Project estimations, Managing time in Agile projects, Work breakdown structure, SPM & Software architecture, Resource needs, Testing project plan, Project management process, Managing quality, Building teams, Managing people, Software development ethics, Tracking and control, Managing objective and scope, Earned value systems, burn-down charts, time boxing, Scrum, Managing Software Assets, Configuration Management , Software Reuse, Change control, Project backlog, Controlling risk, Risk management in Agile projects , Closing the project, Postmortem and Retrospectives.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Construct** software development life cycle and types of software projects
CLO2	**Implement** continuous improvement process using different techniques
CLO3	**Design** project roadmap and software architecture
CLO4	**Test** project plans and software quality assurance
CLO5	**Determine the** software development ethics in project management process

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3			√									
CLO4					√							
CLO5								√			√	

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Software Project Management (5th ed.), Bob Hughes and Mike Cotterell, McGraw Hill, (2009)
2. Applied Software Project Management, Andrew Stellman, Jennifer Greene, O'Reilly Media (2005)

Course No: CSE 6405
Course Title: Software Quality Assurance
Credit: 3.00
Prerequisite: None

Course Content:

Introduction to the software quality assurance (SQA): definition and concepts of SQA; Software quality factors; Software quality components: before, during, and after software development; Software quality metrics; Software quality management process; software development processes & maturity; software testing: testing objectives & testing fundamentals, testing theory, coverage criteria, test management; problem reporting & corrective action, Standards of SQA: International Organization for Standardization (ISO), Capability Maturity Model (CMM).

This course might include an analysis/report generation project in which student will apply the ideas discussed in the course to a particular software problem.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Outline** the definition and concept of SQA, software quality factors and components.
CLO2	**Apply** software quality management process in software development
CLO3	**Perform** software testing objectives, testing fundamentals and test management
CLO4	**Report** problems and undertake corrective actions
CLO5	**Implement** standards of SQA: ISO and CMM in software development

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3					√						√	
CLO4									√			
CLO5			√									

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Software Quality Assurance : From Theory to Implementation- Daniel Galin
2. Metrics and Models in Software Quality Engineering (2nd Edition) - Stephen Kan
3. Handbook of Software Quality Assurance, 3rd Ed. - Schulmeyer, G. Gordon and McManus, James
4. Software Testing - Ron Patton
5. The Self-Taught Software Tester A Step By Step Guide to Learn Software Testing Using Real-Life Project - Chhavi Raj Dosaj

Course No: CSE 6407
Course Title: Software Testing
Credit: 3.00
Prerequisite: None

Course Content:

Introduction to Software Testing, Software testing strategies, Software development life cycle and testing; Testing Techniques: Structural versus Functional Technique Categories, Verification versus Validation, Static versus Dynamic Testing, Regression Testing, Examples of Specific Testing Techniques; Test Administration: Test Planning; Test case generation; Test execution; Test reporting; Defect Management; Test Coverage – Traceability matrix; Automation Testing Basics: Basics of automation testing, Test Tools selection, Test management and bug tracking tools.

Tools:

- Any Software Development Tool (VS.Net - NUnit, Eclipse-JUnit)
- QTP, QC
- TestComplete
- Katalon Studio
- Selenium
- Any emerging practices can be chosen by the instructor (Open)

This course might include practical projects on Test Plan generation, automation or reporting using the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Choose** the software testing strategies
CLO2	**Apply** software development life-cycle in project
CLO3	**Perform** software testing objectives, testing fundamentals and test management
CLO4	**Report** software bugs and fix the problems
CLO5	**Implement** software testing and bug management tools

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2			√									
CLO3			√		√							
CLO4				√								
CLO5					√							

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. *Introduction to Software Testing* (2nd edition), Paul Ammann and Jeff Offutt, Cambridge University Press, 2016.
2. Continuous Delivery: Reliable Software Releases through Build, Test, and Deployment Automation – J. Humble, D. Farley

3. Test Driven Development: By Example – K. Beck
4. Systematic Software Testing- Rick David Craig, Stefan P. Jaskiel · 2002
5. Software Testing and Quality Assurance: Theory and Practice- Kshirasagar Naik, Priyadarshi Tripathy · 2011

Course No: CSE 6409
Course Title: Software Architecture
Credit: 3.00
Prerequisite: None

Course Content:

Introduction to the fundamentals of software architecture. Software architecture: process, specification, measurement, evaluation; Architectural Quality attributes; Fundamental principles and guidelines for software architecture design, styles, patterns and frameworks. Methods, techniques and tools for describing software architecture and documenting design rationale. Software architecture design and evaluation processes. Formal Models and Specifications, Architectural Description Language, Tools for Software Architecture, Designing and Documenting Software Architecture. Approaches and tools for designing and evaluating software architectures for the state-of-the-art technologies. Future challenges and emerging trends in software architecture discipline.

Tools:

- CASE Tools,
- Analysis and Design tools,
- Software Development Tools,
- Software Tools for Architecture Design,
- Processing Tools (Word, Excel, XML etc.)
- Any emerging practices can be chosen by the instructor (Open)

Each student will work on a team project to gain hands-on experience about the development and documentations of a software architecture. Each team has to develop an architecture for a specific system in a given context.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Demonstrate** the fundamentals of software architecture
CLO2	**Describe** the software development principles
CLO3	**Apply** different software architecture models
CLO4	**Make** software architecture designs and documents
CLO5	**Analyze** the state-of-the-art software architectures

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√											
CLO3			√									
CLO4			√									
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Software Architecture: Foundations, Theory, and Practice, - R. N. Taylor, N. Medvidovic, E. M. Dashofy
2. Software Architecture in Practice – L. Bass, P. Clements, r. Kazman
3. Essential Software Architecture, 2nd edition – I. Gorton.
4. Fundamentals of Software Architecture: An Engineering Approach – M. Richard, N. Ford

Course No: CSE 6411
Course Title: Object Oriented Analysis and Design (OOAD)
Credit: 3.00
Prerequisite: Object Oriented Programming*
Course Content:

Theory: Introduction to Software Modeling and UML; The requirements analysis, Use Case Diagram; Inheritance and polymorphism, Interfaces and components, Class Diagram; CRC Cards; Relationship,

Sequence Diagram, Object Diagram and Collaboration Diagram, Activity Diagram; Data flow diagram level 1, 2 & 3, ERD and Schema, State machines, State-chart Diagram; Component Diagram; Deployment Diagram; COCOMO (The Constructive Cost Model-Software Project Estimation); Object-Oriented Software metrics; Introduction to Design Patterns; Project using UML, Deployment and Testing.

Tools: (Instructor may choose among the options.)

- draw.io
- erdplus
- creately

This course shall include the diagram and designs which are necessary to build a software.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the object-oriented programming
CLO2	**Describe** the UML, ER diagram, activity diagram and use cases
CLO3	**Compare** object-oriented model of a software project
CLO4	**Make** OOP related diagrams using modern tools
CLO5	**Design** object-oriented software metrics

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√											
CLO3			√									
CLO4			√		√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Erich Gamma, John Vlissides, Richard Helm, Ralph Johnson, "Design Patterns: Elements of Reusable Object-Oriented Software", Addison-Wesley
2. Bhuvan Unhelkar "UML distilled", Addison-Wesley
3. Craig Larman "Applying UML and patterns", Pearson Education
4. John Skelton, Ken Lunn, Simon Bennett, "Schaum's Outline of UML", McGraw-Hill
5. Jim Arlow, Ila Neustadt"UML 2 and the Unified Process: Practical Object-Oriented Analysis and Design", Addison-Wesley

Course No: CSE 6413
Course Title: Advanced Object-Oriented Programming (AOOP)
Credit: 3.00

Course Content:

Theory: Introduction to Object-Oriented Design and Analysis, Class and Objects, Encapsulation, Information Hiding, Unit Testing, Interfaces and Polymorphism, Introduction to Design Patterns (Observer, Strategy, Composite, Decorator, Iterator, Adaptor, Command, Factory Method, Proxy, Singleton, and Visitor), Inheritance, Virtual Functions, More Polymorphism, Abstract Classes, Cloning Objects, Serialization of Objects, Object Oriented Frameworks, Concurrency and Multi-threading, Synchronization of access to objects. Students will apply the knowledge of Advanced Object-Oriented Programming to homework assignments and group/individual projects throughout the course.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the advanced object-oriented programming concept
CLO2	**Describe** the OOP terminologies
CLO3	**Construct** object-oriented model of a software project
CLO4	**Compare** software using OOP frameworks
CLO5	**Analyze** object-oriented design patterns and frameworks

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√											
CLO3			√									
CLO4			√		√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Erich Gamma, John Vlissides, Richard Helm, Ralph Johnson, "Design Patterns: Elements of Reusable Object-Oriented Software", Addison-Wesley
2. Craig Larman "Applying UML and patterns", Pearson Education
3. Elisabeth Freeman, Kathy Sierra "Head First Design Patterns", Head First EJB
4. Dusty Phillips "Python 3 Object Oriented Programming", Packt Publishing
5. Herbert Schildt "Java: The Complete Reference", McGraw-Hill

Course No: CSE 6415
Course Title: Information System and Business Process
Credit: 3.00
Prerequisite: None
Course Content:

Theory: Introduction to Information Systems, Business Process and Decision Making, Productivity, Innovation, and Strategy: Introduction & Overview of Group Project, Database and Content Management, Acquiring Information Systems through projects, Networks and Collaboration, Business Process Flow Charts, Competitive Advantage and Business Processes, Decision Making and Business Intelligence, e-Commerce, Social Networking, and Web 2.0, Structure, Governance and Ethics Managing Information Security and Privacy.

Group Project:

Phase 1 – Project Plan
Phase 2 – Business Requirement Engineering
Phase 3 – Process Flow
Phase 4 – Information System Build
Phase 5 – Final Submission & Presentation

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the information systems and business process
CLO2	**Combine** database and content management
CLO3	**Make** a group project
CLO4	**Apply** information systems in decision making
CLO5	**Analyze** business intelligence, e-commerce, and social networking

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√											
CLO3			√						√			
CLO4				√								
CLO5				√								√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

Reference:

1. Kroenke, Gemino, Tingling Experiencing MIS, Fourth Canadian Edition with MyITLab, Pearson Education, 2015.
2. Business Process Management: Concepts and Applications" by Jörg Becker, Martin Kugeler, and Michael Rosemann.
3. Business Process Modeling, Simulation and Design" by Manuel Laguna and Johan Marklund.
4. Information Systems for Business: An Experiential Approach" by France Belanger and Craig Van Slyke.

Course No: CSE 6417
Course Title: E-Commerce and Web Engineering
Credit: 3.00
Course Content:

Theory: Web system and programming: Web system overview, HyperText Transfer Protocol (HTTP), Load balancing, Caching, HyperText Markup Language (HTML), Client-side programming, Server-side programming. Cryptography: security requirements, asymmetric key encryption, symmetric key encryption, message digest, digital signature, digital certificate, public key infrastructure. Internet security: IPSec, Firewall, Secure Socket Layer (SSL) Protocol/Transport Layer Security, Application layer security, Internet payment systems: Secure electronic transaction (SET), Electronic cash, Electronic check, Micropayment methods, Smart card. E-commerce applications: Business models, Consumer oriented e-commerce, Business-oriented e-commerce, Case studies and examples. Advanced/current topics: e.g. Mobile agent-based ecommerce, m-commerce.
This course shall include practical projects on E-commerce by the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the concept of web engineering
CLO2	**Extend** the HTTP, HTML, client, server, and cryptography
CLO3	**Make** web servers and clients using modern web engineering tools
CLO4	**Apply** web programming in e-commerce and mobile commerce
CLO5	**Improve** web security

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2	√											
CLO3			√									√
CLO4			√				√					
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Ravi Kalakota, Andrew Winston, "Frontiers of Electronic Commerce", Addison Wesley
2. Pete Lohsin , John Vacca "Electronic Commerce", New Age International
3. Goel, Ritendra "E-commerce", New Age International
4. Laudon, "E-Commerce: Business, Technology, Society", Pearson Education
5. Bajaj and Nag, "E-Commerce the cutting edge of Business", TMH
6. Turban, "Electronic Commerce 2004: A Managerial Perspective", Pearson Education

Course No: CSE 6419
Course Title: Design & Development of Open Multi-tier Application
Credit: 3.00
Prerequisite: None

Course Content:

Theory: Introduction to Multi-Tier Design, 3- Tier Design: Presentation Tier, Logic Tier, Data Tier, N- Tier Design, Overview of Designing a Multi-Tier Solution, Connectivity Within The VPC, Design Components - EC2 and Elastic Load Balancers, Design Components - Auto Scaling, Serverless Design Patterns, Microservice Design Patterns, Future of Open Multi-Tier Application: Cloud.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the multi-tier software design
CLO2	**Illustrate** the 3-tire software design
CLO3	**Make** multi-tire software and connect the microservices
CLO4	**Apply** load balancers and auto scaling for applications
CLO5	**Modift** multi-tier and monolithic design

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√		√							
CLO4			√		√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Professional ASP.NET Design Patterns by Scott Millett
2. Enterprise Application Architecture by martin flower
3. Java Enterprise in a Nutshell: A Desktop Quick Reference" by Jim Farley, William Crawford, David Flanagan, and Kris Magnusson.
4. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems" by Martin Kleppmann.
5. Enterprise JavaBeans 3.1" by Bill Burke, Richard Monson-Haefel.

Course No: CSE 6421
Course Title: Interactive Multimedia Design and Development
Credit: 3.00
Prerequisite: None

Course Content:

Theory: Introduction of course development software, electronic courseware planning, design and development stages, screen design principles, digital image/audio/video software, animation, user interaction, feedback techniques, navigation, multimedia courseware packaging, evaluation. Creating, publishing and evaluation of multimedia applications. This course introduces students to the design and production process of developing interactive multimedia, a combination of text, sound, animation, graphics, and video. Students will be given an opportunity to work with a variety of software including programs used for sound and video production, multimedia presentations & image editing. Students will apply the knowledge to complete homework, assignments, or small projects throughout the course.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the multi-media design and development strategies
CLO2	**Apply** design and development stages of multi-media
CLO3	**Make** multi-media applications, animations, graphics and videos
CLO4	**Examine** multi-media design and development strategies for projects
CLO5	**Analyze** multi-media applications and strategies

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1		√										
CLO2		√									√	
CLO3			√		√							
CLO4			√		√							
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Mayer, R. E. (2001). Multimedia learning. Cambridge: Cambridge University Press. MA: Course Technology.
2. Heinich, R., Molenda, M., Russell, J. D., & Smaldino, S. E. (1999).
3. Instructional media and technologies for learning. Upper Saddle River, NJ: Prentice-Hall. Alessi,S. & Trollip,S.(2001)
4. Multimedia for Learning . Needham, MA: Allyn & Bacon, 2001 Mayer, R. (2005).
5. The Cambridge Handbook of Multimedia Learning. New York: Cambridge University Press
6. Adobe Fireworks CS5 Classroom in a Book:Adobe Training book
7. Audacity. The Free, Cross-Platform Sound Editor (http://audacity.sourceforge.net)

Course No: CSE 6423
Course Title: Computer Graphics and Animation
Credit: 3.00

Course Content:

Theory: Introduction, Motivation, Uses, History of Computer Graphics Systems and Models, Graphics Programming : Getting started with OpenGL, Input and Interaction in OpenGL, Geometrical Objects and Transformations in 2D and 3D, homogeneous coordinates, matrix representation, windows and viewports, Viewing in 3D projections, hidden surface removal, Light, shading and materials, Illumination and Shading, light sources, Introduction to Computer animation, Basic and advanced mesh modelling, Materials and lighting, Texture mapping, Character animation, Key-frame based animation, Rigging and posing, Walking and running, Motion capture based animation, Particle system, Fluid, Hair, Cloth, Deformable models, Motion tracking, Dynamic paint, Future of Computer Graphics and Animation.

This course shall include practical projects on Computer Graphics and Animation by using the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the computer graphics
CLO2	**Develop** 2D and 3D object geometry
CLO3	**Make** computer animations
CLO4	**Apply** light and shading in computer graphics
CLO5	**Use** the modern computer graphics tools

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2	√											
CLO3			√		√							
CLO4			√		√							
CLO5					√							√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Interactive Computer Graphics: A Top-Down Approach with OpenGL by Edward Angel, 4th edition
2. The OpenGL Programmer's Guide (the Redbook), Addison-Wesley
3. The OpenGL Reference Manual (the Bluebook), Addison-Wesley
4. Computer Graphics: Principles and Practice" by John F. Hughes, Andries van Dam, Morgan McGuire, David F. Sklar, James D. Foley, Steven K. Feiner, and Kurt Akeley.

Course No: CSE 6425
Course Title: Smart Phone Application Development
Credit: 3.00

Course Content:

Theory: Introduction to the Android platform and the Android Studio IDE, Android components, Activities, Intents, Activity lifecycle, UI Design: Widgets and Layouts, UI Events, Event Listeners, Drawables, Basics of Material Design, 2D graphics: Canvas/Drawing using a view, Audio playback and MediaPlayer, Sound Pool, Basics of networking in Android, AsyncTask, HttpURL Connection.

This course shall include practical projects on Smart Phone Application Development by using the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Understand** the smartphone platforms and IDEs
CLO2	**Develop** the concept of activity lifecycle, UI, widgets and layouts
CLO3	**Make** applications for smartphone
CLO4	**Apply** 2D graphics and material design in applications
CLO5	**Design** the modern IDEs to make applications

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2	√											
CLO3			√		√							
CLO4			√		√							
CLO5					√							√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Android Application Development All-in-One For Dummies by Barry A. Burd
2. Android developer manual: https://developer.android.com/docs
3. Android Programming: The Big Nerd Ranch Guide" by Bill Phillips and Brian Hardy.
4. Professional Android 4 Application Development" by Reto Meier.

Course No: CSE 6427
Course Title: Computer Game Design and Development
Credit: 3.00

Course Content:

Theory: A Brief History of Video Games, Games and Society, Game Design, Teams and Processes, Programming Fundamentals, Debugging Games, Game Architecture, Memory and I/O Systems, Mathematical Concepts, Collision Detection and Resolution, Game Graphics, Artificial Intelligence, Networks and Multiplayer Mode, Future of Game Development Sector.

This course shall include practical projects on Computer Game Design and Development by using the framework mentioned above or any other state-of-the-art techniques.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the history of video games
CLO2	**Show** the game architecture, console and I/O
CLO3	**Make** games for smartphone
CLO4	**Apply** physics and mathematical concept of real world in games
CLO5	**Analyze** the offline & networks and single & multiplayer games

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3			√		√							
CLO4			√									
CLO5				√								

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

Reference:

1. Introduction to Game Development 2nd Edition by Steve Rabin
2. Game Programming Patterns" by Robert Nystrom.
3. The Art of Game Design: A Book of Lenses" by Jesse Schell.
4. The Ultimate Guide to Video Game Writing and Design" by Flint Dille and John Zuur Platten.

Course No: CSE 6429
Course Title: Enterprise Resource Planning
Credit: 3.00
Prerequisite: Software Engineering*

Course Content:

Theory: Introduction to ERP, SAP System Access & Display Settings, SAP Operation Overview, Understand a Company's Supply Chain (SAP Navigation), Business Processes, Information Systems, and Information, Accounting and Business Environment, Financial Accounting Information System, Using IS

to Improve Processes, Recording Business Transactions, Supporting Processes with ERP Systems, Procurement Process, Procumbent Planning & Production Planning, Supporting the procurement Process with SAP, Sales and Distribution Process, Supporting the Sales Process with SAP, Production Processes, Improve Performance Utilizing Business Intelligence (Real Time Analytics & Data Visualization), Real-Time Business Intelligence & Analytics using oData Service, Business Intelligence and IS.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the ERP and SAP systems
CLO2	**Identify** the business process and information systems
CLO3	**Understand** sales and distribution process
CLO4	**Making a plan** business performance using business intelligence
CLO5	**Analyze** the real time business data using Data service

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√										
CLO3		√										
CLO4				√								
CLO5				√		√						

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Processes, Systems, and Information: An Introduction to MIS, 3rd Edition (ISBN-13: 9780134827001), by Earl H. McKinney and David M. Kroenk.
2. Horngren's Accounting, The Financial Chapters, 12th Edition (ISBN-13:9780134490540), Tracie L. Miller-Nobles, Brenda L. Mattison, Ella Mae Matsumura.

3. Introduction to Enterprise Resource Planning (ERP) (digital collection ISBN: 9781323923481), Custom Textbook Pearson Publishing. The textbook can be purchased from Pearson Publishing (https://console.pearsoned.com/enrollment/usomgl.
4. Oracle E-Business Suite Financials Handbook" by Ben Prusinski and Gustavo Gonzalez.

Course No: CSE 6431
Course Title: Engineering Ethics
Credit: 3.00
Prerequisite: None

Course Content:
Theory: Ethics: Introduction and overview, Morals and ethics, Comparison of ethics and engineering ethics, Ethics at personal and student level, Professions: Concept of professions, Importance of ethics in science and engineering, Role of codes of ethics, Professional responsibilities of engineers, Morality: Concept of morality, Core values, Moral/ethical dilemmas and hierarchy of moral values, Factors affecting moral responsibility, degrees of responsibility, Ethical Theories: Overview of ethical theories and applications, Ethical analyses and decision-making, Ethical leadership in engineering and society, Conflicts of interests, Engineers in organizations, Ethics in the workplace, Fairness (personal and social), Reliability, risk and safety, Risk management, Resource allocations, Ethics in the electronic and digital age, Privacy and confidentiality issue, Responsible conduct of research, Intellectual property and society, Ethics and the environment, Innovation and ethics, Sustainable engineering, Global and cultural considerations.

Course Learning Outcomes (CLOs): At the end of the course, students will be able to-

CLOs	Statements
CLO1	**Describe** the morals and ethics
CLO2	**Explore** the morality and core values
CLO3	**Understand** degrees of responsibilities
CLO4	**Analyze** the ethics and engineering ethics
CLO5	**Justify** engineering ethics in workspace

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs):

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	√											
CLO2		√						√				
CLO3						√						
CLO4				√				√				
CLO5								√				√

Mapping of CLOs with the Teaching-Learning

CLOs	Teaching-Learning Strategy
CLO1	Lecture, multimedia
CLO2	Lecture, Group discussion
CLO3	Lecture, Problem Solving, Group discussion
CLO4	Problem Solving
CLO5	Multimedia

Mapping of CLOs with Assessment Strategy

CLOs	Assessment Strategy
CLO1	Written Examination, Assignment
CLO2	Quiz, Written Examination
CLO3	Quiz, Presentation, Viva, Written Examination
CLO4	Quiz, Assignment, Written Examination
CLO5	Quiz, Written Examination

References:

1. Engineering Ethics, Charles B. Fleddermann, Prentice Hall
2. Fundamentals of Ethics FOR SCIENTISTS AND ENGINEERS, Edmund G.Seebauer, Robert L. Barry, oxford university press.
3. Ethics in Computing, Science,and Engineering, Barry G. Blundell, Springer
4. Introduction to Engineering Ethics, Mike W. Martin, Roland Schinzinger, McGraw-Hill Higher Education

Course No: CSE 6433
Course Title: Courses of Current Interest/Special Topics Related to Software Engineering
Credit: 3.00
Prerequisite: None

Course Content:

Any expert proposed by the department and approved by syllabus committee will conduct this course. A subtitle and content shall be determined and approved by the same committee. In the transcript of the students the subtitle will follow the main title (Example: M*CSE 6213 Special Topic –I: Big Data*).

PART D: GRADING/EVALUATION

4.1 Assessment/ Evaluation procedure

I. The total performance of a student in each course is based on class assessment (assignments, attendance, and projects), a mid-semester examination, and a semester final examination. The percentile distribution of marks for a theoretical course is as follows:

Class Assessment	15%
Project/Assignment/Presentation/ Case study/Paper writing etc.	20%
Mid Semester Examination	25%
Final Examination	40%
Total	100%

4.2 Grading System

Final grades for courses shall be recorded as follows:

Numerical Grade	Letter Grade	Grade Point
80% and above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
Incomplete Work	I	---
Satisfactory	S	---
Unsatisfactory	U	---
Withdrawn	W	---

Courses in which the student gets F grades shall not be counted towards credit hour requirements and for the calculation of Grade Point Average (GPA).

Grade I is given only when a student is unable to sit for the examination of a course at the end of the semester because of circumstances beyond his control. She/he must apply to the Head of the Department within one week after the examination to get an I grade in that course. If it is not completed within the next two semesters, then the I become an F grade. She/he may, however, be allowed to register without further payment of tuition fees for that course. Only final grades of S (satisfactory) or U (unsatisfactory) are utilised for thesis/projects and non-credit courses. The grade for the thesis/project "In Progress" will be reported accordingly. If the thesis or project is not completed, and I grade will be assigned.

The grade W means officially withdrawn from a course. A student must withdraw officially from a course within two working weeks of the commencement of the semester or else his grade in that course shall be recorded as F unless she/he is eligible to get a grade of I.

A student's semester performance is evaluated by Grade Point Average (GPA), which is computed in the following manner:

$$GPA = \frac{\sum(Grade\ Point\ X\ Credits)}{\sum Earned\ Credits}$$

The grade points are points against letter grades as shown earlier. Credits are only for those courses registered for at UAP.

III. Students may enroll for non-credit course(s) termed as audit course(s) on the recommendation of her/his thesis/project Supervisor/Advisor. However, her/his grade for such course(s) will not be counted for calculating her/his GPA.

4.3 Conduct of Examination

I. In addition to tests, assignments and/or examinations during the semester as may be given by the teacher(s) concerned, there will be a written examination and/or other tests for each of the subjects offered in a semester at the end of that semester, the dates of which will be announced by the Controller of Examinations, UAP as advised by the BPGS at least two weeks prior to the commencement of the examination.

II. The Controller of Examinations must preserve an up-to-date record of all the grades obtained by a student in an individual Academic Record Card. The Controller of Examinations will release grades at the end of each semester. In addition, each student is entitled to one official transcript of the

university record without any fee at the completion of his academic program from the office of the Controller of Examinations on the production of statement of clearance from all Departments/Offices.

III. The BPGS of the Department must recommend the names of the paper setters and examiners for the semester examinations at least two weeks prior to the exam's start date.

4.4 Qualifying Requirements

The qualifying requirement for graduation is that a student must earn a minimum grade point of **2.50** based on the weighted average in his course work. **If a student fails to maintain the minimum CGPA requirement for graduation, he may apply for improvement of grades for the subjects with grade C+ or lower.** However, the number of subjects will be limited to two for Master of Science in Computer Science and Engineering and three for Master of Engineering in Computer Science and Engineering respectively.

4.5 Thesis

I. Research work for a thesis shall be carried out under the supervision of a full-time faculty member of the Department of CSE. However, in special cases, a full-time member of the staff belonging to a department outside the Department of CSE or an Institute/Center of the university may be appointed as Supervisor if the research content of the thesis is within the field of such a Department/Institute/Center. A co-supervisor from within or outside the Department may be appointed, if necessary. The thesis proposal of a student shall be submitted to the BPGS for approval after the completion of at least 12 credit hours of course work.

II. If any change is necessary for the approved thesis (title, content, cost, Supervisor, Co-supervisor, etc.), it shall be approved by the Supervisor and notified to the BPGS.

III. The proposed research must take place at this university or at a place(s) approved by the BPGS in consultation with the Supervisor. The thesis should show that the student has sufficient understanding in the topic of research that he or she is working on. The student must declare that the research project was completed by her/him and that this work has not been submitted for any other diploma or degree.

IV. Every student must submit to the Master's Coordinator, through his Supervisor, the required number of typewritten copies of his thesis in the approved format on or before a date to be decided by the Head of the Department in consultation with the concerned Supervisor.

V. Every student submitting a thesis in partial fulfillment of the requirements of a degree, shall be required to appear at an oral examination, on a date or dates fixed by the Master's Coordinator and must satisfy the examiners that she/he is capable of intelligently applying the results of this research to the solution of problems, of undertaking independent work, and also afford evidence of satisfactory knowledge related to the theory and technique used in her/his research study.

4.5.1 Examination Board for Thesis

I. An Examination Board for every student for thesis defense and oral examination shall be approved by the BPGS on the recommendation of the thesis Supervisor in consultation with the Master's Coordinator. The Supervisor shall act as the Chairman, and the Master's Coordinator will be a member secretary of the Examination Board. The Board shall consist of at least four members, including the Head of the Department, Master's Coordinator, and the Supervisor. The Examination Board shall be constituted as follows:

i. Supervisor	Chairman
ii. Co-supervisor (if any)	Member
iii. Head of the Department of CSE	Member
iv. One member from within the CSE Department	Member
v. One external member from outside the CSE Department	Member
vi. Master's Coordinator	Member Secretary

II. If any examiner is unable to accept the appointment or needs to relinquish his appointment before the examination, Master's Coordinator shall appoint another examiner in his place, on a suggestion from the Supervisor in consultation with the Head of the Department.

4.6 Project

II. Project work shall be carried out under the supervision of a full-time faculty member of the Department of CSE. However, in special cases, a full-time member of the staff belonging to a department outside the Department of CSE or an Institute/Center of the university may be appointed as Supervisor if the research content of the project is within the field of such a

Department/Institute/Center. The title of the project, cost, and the Supervisor will be recommended by the BPGS.

VIII. The project work must be carried out in this university or at a place approved by the Supervisor in consultation with the Master's Coordinator. The student shall certify that the project work was done by her/him and that this work has not been submitted elsewhere for any other degree or diploma.

IX. Every student must submit to the Master's Coordinator, through his supervisor, required number of typewritten copies of her/his project report in the approved format on or before a date to be decided by the Master's Coordinator in consultation with the concerned Supervisor.

X. Every student submitting a project report in partial fulfillment of the requirement of a degree shall be required to appear at an oral examination, on a date or dates fixed by the Master's Coordinator and must satisfy the examiners that s/he has gained satisfactory knowledge related to the project work.

4.6.1 Examination Board for Project

I. An Examination Board for every student for the project and oral examination shall consist of at least three members, including the Supervisor. The Supervisor shall act as the Chairman. The BPGS shall recommend the names of the examiners for approval of the Head of the Department. The Examination Board shall be constituted as follows:

i. Supervisor	Chairman
ii. One member from within the Department of CSE	Member
iii. One member from within or outside the CSE Department	Member
iv. Master's Coordinator	Member

If any examiner is unable to accept the appointment or needs to relinquish his appointment before the examination, Master's Coordinator shall appoint another examiner in his place, on a suggestion from the Supervisor in consultation with the Head of the Department.

4.7 Academic Fees

Academic fees are set by the university authority, based on a recommendation from the Academic Monitoring and Coordination Committee (AMCC). The tuition fees will be based on:

i. Caution Money (refundable): Payable at the time of admission.

ii. Course Fee: To be paid at the beginning of each semester per credit hour basis.

4.7.1 Striking off and Removal of Names from the Rolls

The name of the student will be struck off and removed from the rolls of the university on the following grounds:

i. Non-payment of dues within the prescribed period.

ii. Failing to proceed with the program as per the rules.

iii. Failing to make satisfactory progress in her/his program as per the rules.

iv. Forced to discontinue her/his studies under disciplinary rules.

v. Withdrawn officially from all the courses including thesis/project.

4.8 Course Registration

A regular student is normally required to take a minimum of 09 credits and a maximum of 12 credits in a regular semester. The regular period of course registration starts a week before the commencement of semester classes and extends up to two weeks after the semester begins.

4.9 Performance Evaluation and Award of Degree

The performance of a student will be evaluated in terms of GPA and cumulative grade point average (CGPA), which is the weighted grade point average for all the courses completed. Students will be making normal progress towards a degree if their CGPA for all the theory courses completed is 2.5 or better and are in good standing with the university.

4.10 Admission Office

Detailed information regarding the admission requirements and procedure is available at the admission office of UAP, which is located on Green Road of the campus, with the following postal address:

74/A, Green Road, Dhaka - 1215

PABX: + 880-2-58157091- 4 , + 880-2-58157096

FAX : + 880-2-58157097

Email: admission@uap-bd.edu, asst.reg-admission@uap-bd.edu

4.11 Fees

During admission, the students need to pay the admission fee, caution money, co-curricular activities fee, certificate verification and ID fee, tuition fee (for courses to be registered in the 1st semester), and convocation fee. The caution money will be returned to the students after completion of the study. Fees may change from time to time upon approval of the UAP Authority.

4.12 Tuition Fee Payment Procedure

Students are expected to pay all dues before the start of an academic semester as per the prescribed schedule decided by the Registrar.

4.13 Withdrawal of Courses

Students may withdraw courses within two weeks of commencement of classes of a semester. For further details of the academic rules, students should consult the university information booklet for Examination Rules and Procedures.