Outcome-based Curriculum of Master of Science in Computer Science and Engineering

Computer Science and Engineering Discipline
Khulna University
November 2022

OUTCOME-BASED CURRICULUM

PART- A

01. Title of the Academic Program

Masters of Science in Computer Science and Engineering

Program Overview	
Degree	Masters of Science in Computer Science and Engineering
Abbreviated form of the Degree	M.Sc. in CSE (Thesis) M Engg. in CSE (Project) M Engg. in CSE (Internship)
Discipline/Program Offering Entity (POE)	Computer Science and Engineering Discipline
School	Science Engineering and TechnologySchool
Awarding Institution	Khulna University
Location	Khulna, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	7
International Standard Classification of Education (ISCED) Code	0714
Mode of Study	Full Time
Language of Study	English
Applicable Session	2022-2023 and onwards

02. Name of the University

Khulna University

03. Vision of the University

Khulna University strives to create a knowledge-based just society through accelerating inclusive and transformative growth of Khulna, Bangladesh and the world. The university aims to achieve this vision through cross-cutting research, scholarly enquiry and development of new knowledge.

04. Mission of the University

SL.	University Missions
UM1	Explore human potential to the fullest extent and produce self-motivated, aspiring leaders to work for the betterment of the humankind based on wisdom, freethinking, creativity and unhindered intellectual exercises.
UM2	Ensure a transformative educational experience that enables creative learning, entrepreneurship and inquisitiveness among the students.
UM3	Create an inclusive research environment that enables graduates to make demonstrable economic and social impacts through translating knowledge and innovation into practice driven by moral values and professional ethics.

UM = University Mission

05. Name of the Discipline/Program Offering Entity (POE)

Computer Science and EngineeringDiscipline

06. Vision of the Discipline/POE

To be one of the global leaders in the fields of CSE and ICT through quality education, excellent research, and innovation for the sustainable transformation of the society.

07. Mission of the Discipline/POE

No.	Description
M1	To provide a comprehensive educational experience for the students by incorporating in-depth domain knowledge, problem-solving capabilities, communication skills, technology-adaptation competency, and leadership guidelines.
M2	To conduct high quality state of the art research for creating, exploring, and sharing cutting edge knowledge of CSE and ICT fields for the welfare of mankind.
M3	To develop potential candidates for world famous high-tech industries, research, and educational institutions.
M4	To make students aware of ethical responsibilities, social obligations, diversity, and economic challenges.

M = Mission of the Discipline/POE

08. Objectives of the Discipline/POE

No.	Description
O1	To teach students to solve ICT problems efficiently, effectively, innovatively, and intelligently
O2	To develop the students to use the techniques, skills and modern hardware and software engineering tools
O3	To offer state of the art prospectuses to the students in both technical and scientific knowledge for the professionals and academics
O4	To build the future leadership for technological industries at the national and international levels.

O = Objective of the Discipline/POE

09. Name of the Degree

Masters of Science in Computer Science and Engineering

10. Description of the Program

"Observe national & global trends, identify scope, produce market-ready graduates, and innovate for future" – that's the only way today's disciplines need to function; Computer Science and Engineering (CSE) discipline, Khulna University also follows this motto. Currently, our goal is to contribute in the process of achieving success in the 4th industrial revolution as well as to face the challenges of the 21st century.

In 1991, Computer Science and Engineering (CSE) Discipline of Khulna University (KU) started its academic activities with only 20 undergraduate students. Since then, around 850 undergraduate students have graduated from this Discipline. A perfect 100% proud graduates are working in different government and private organizations as well as in teaching professions in home and abroad.

Since its establishment, more than 850 students have graduated and are proudly working in the IT sector of various government and non-government organizations as well as in the teaching profession at home and abroad. At present, the discipline offers undergraduate & postgraduate programs including PhD programs. Faculties of CSE discipline have earned their PhDs from all over the world such as Canada, Australia, Japan, France, Norway, Korea, Malaysia, and etc. Faculty members with diverse interests are committed to research & innovation. At present, faculties of CSE are researching on the field of computer vision, machine learning, networking, software engineering, natural language processing, and so on.

This discipline provides quality education in both theoretical and applied fields and trains students to apply this education effectively to solve real-world problems. However, we firmly believe that academic learning can't facilitate in producing complete national & global citizens. Thus, we have traditions of several mechanisms such as club activity, festival celebrations, study tours, and etc., to build up fully functional citizens. We also encourage students to participate in various sports for learning leadership-skills and team-work. Students of CSE are operating a computer club named Club for Updated Search on Computer (CLUSTER). CLUSTER arranges online/offline seminars, CSE Fests, programming contests and publishes IT magazines. Faculty members guide students to participate in competitions. Financial mechanisms are in place to facilitate students participating in both research and competitions.

A strong alumni community is helping graduates to be placed in big giants both in home and abroad. Furthermore, their continuous support helps students in need. They guide students to get hands-on knowledge about cutting edge technologies.

Finally, the discipline is in motion to achieve its maximum potential and contribute to society with utmost desire. An active student centric environment is promised to students. We're looking forward to growing more through continuous creation and distribution of knowledge.

11. Graduate Attributes

No.	Description	Domain
GA1	**A knowledge base for engineering:** Demonstrated competence in mathematics, engineering fundamentals, and specialized engineering knowledge appropriate to computer science and engineering.	Fundamental domain
GA2	**Problem analysis:** An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex computational problems	Thinking Domain
GA3	**Investigation:** An ability to investigate complex engineering problems by appropriate experiments, analysis and interpretation of data, and synthesis of information.	Thinking Domain
GA4	**Design:** An ability to design software and hardware solutions for complex, open-ended engineering problems.	Thinking Domain
GA5	**Use of engineering tools:** An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools.	Fundamental Domain
GA6	**Individual and team work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.	Social domain
GA7	**Communication skills:** An ability to communicate complex computer science and engineering concepts within the profession and with society at large.	Personal Domain

GA8	**Professionalism:** An understanding of the roles and responsibilities of the professional computer engineer in society.	Personal Domain
GA9	**Impact of engineering on society and the environment:** An ability to analyze social and environmental aspects of science and engineering activities.	Social Domain
GA10	**Ethics and equity:** An ability to apply professional ethics, accountability, and equity.	Personal Domain
GA11	**Economics and project management:** An ability to appropriately incorporate economics and business aspects including project, risk, and change management into the practice of engineering and to understand their limitations.	Personal Domain
GA12	**Life-long learning:** An ability to identify and address their own educational needs in a changing world in ways sufficient to maintain their competence and allow them to contribute to the advancement of knowledge.	Personal Domain

GA = Graduate Attributes

12. Program Educational Objectives (PEOs)

No.	Description
PEO1	To prepare students for applying in-depth and upto-date computer science and engineering knowledge and analytical skills to initiate innovative solutions for the society.
PEO2	To enable students quest for learning, establishing collaborations, and engaging in continuous professional development in the field of computer science and engineering by carrying research and adopting professional practice.
PEO3	To attain the ability for becoming adaptive in multidiscipline and multicultural environment and work effectively as a team lead or team member possessing strong soft skills and high moral ethics. (

PEO = Program Educational Objective

13. Program Learning Outcomes (PLOs)

After successful completion of the degree, the learner will beable to:

A. Fundamental Skills	
PLO1	Apply breadth of knowledge in computer science in the subject areas of Foundations, Architecture, Systems Software, Software Engineering etc.
PLO2	Gain depth of knowledge in an advanced topic in computer science, including the ability to carry out original work that builds upon the existing body of knowledge in the field.
B. Social Skills	
PLO3	**D**emonstrate the leadership quality in teamwork and in multi-disciplinary environment.
PLO4	**Develop a**bility to communicate effectively both orally and in writing Computer Science and Engineering topics to researchers, practitioners, and the public.
C. Thinking Skills	
PLO5	Demonstrate an understanding of advanced knowledge of the practice of computer engineering, from vision to analysis, design, validation, and deployment.
PLO6	Tackle complex engineering problems and tasks by adopting contemporary engineering principles, methodologies and tools.
D. Personal Skills	
PLO7	Be aware of ethical, economic, and environmental implications of their work, as appropriate.
PLO8	Advance successfully in the engineering profession and sustain a process of life-long learning in engineering or other professional areas.

PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs

Missions / PEOs	UM1	UM2	UM3
PEO1	√	√	√
PEO2	√	√	√
PEO3	√	√	√

15. Mapping PLOs with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)		
		PEO1	PEO2	PEO3
A. Fundamental Domain	PLO1	●	●	
	PLO2	●	●	
B. Social Domain	PLO3			●
	PLO4	●	●	
C. Thinking Domain	PLO5	●	●	
	PLO6	●	●	
D. Personal Domain	PLO7			●
	PLO8	●	●	

16. Mapping Courses with PLOs

Course Code and Course Title	PLOs							
	Fundamental Domain		Social Domain		Thinking Domain		Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
First Year First Term								
0111 02 Edu 5151 Research Methodology and Ethics		●		●	●	●	●	●
0111 02 Edu 5152 Seminar	●	●	●	●	●	●		
0714 02 CSE 5101 Advanced Probability and Statistics	●	●	●		●	●		●
0714 02 CSE 5103 Graph Theory	●	●	●	●	●	●	●	
0714 02 CSE 5105 Advanced Bioinformatics	●	●	●	●	●			
0714 02 CSE 5107 Advanced Numerical Analysis	●	●	●	●	●	●		●
0714 02 CSE 5109 Advanced Software Engineering	●		●	●		●		
0714 02 CSE 5111			●	●	●			

Software Testing and Quality Assurance								
0714 02 CSE 5113 Computer Communications and Networks	●	●			●	●		●
0714 02 CSE 5115 Advanced Cloud Computing	●	●	●		●		●	●
0714 02 CSE 5117 Advanced Internet of Things	●	●	●	●	●	●	●	●
0714 02 CSE 5119 Petri Net Theory and Modeling of Systems	●	●		●	●	●		
0714 02 CSE 5121 Advanced Machine Learning	●	●	●	●	●	●		
0714 02 CSE 5123 Evolutionary Algorithms	●	●	●	●	●			
0714 02 CSE 5125 Neural Networks	●	●	●	●	●	●		●
0714 02 CSE 5127 Statistical Natural Language Processing	●	●	●	●	●	●	●	●
0714 02 CSE 5129 Multimedia Systems and Communications	●	●		●	●	●		●
0714 02 CSE 5131	●	●		●	●	●		●

Computer Graphics and Animation								
0714 02 CSE 5133 Advanced Computer Vision	●	●		●	●			●
0714 02 CSE 5135 Ubiquitous Computing	●	●	●	●	●	●	●	●
0714 02 CSE 5137 Advanced Logic Design	●	●			●	●		
0714 02 CSE 5139 Optimization Theory	●	●			●	●		●
First Year Second Term								
0714 02 CSE 5201 Advanced Algorithms	●	●	●	●	●			
0714 02 CSE 5203 Computational Geometry	●	●	●	●	●	●	●	
0714 02 CSE 5205 Control Theory	●	●		●	●	●		●
0714 02 CSE 5207 Engineering Mathematics	●	●	●	●	●	●	●	●
0714 02 CSE 5209 Queuing Theory	●	●				●		●
0714 02 CSE 5211 Software Evolution and Maintenance		●	●				●	●
0714 02 CSE 5213	●	●			●	●		●

Wireless Ad-Hoc and Sensor Networks								
0714 02 CSE 5215 Future Internet	●	●			●	●		●
0714 02 CSE 5217 Advanced Information security	●	●	●	●	●			
0714 02 CSE 5219 Game Theory in Wireless and Communication Network	●	●			●	●	●	●
0714 02 CSE 5221 Blockchain Technology and Applications	●	●	●	●	●	●		●
0714 02 CSE 5223 Temporal Logic and Model Checking	●	●			●	●		
0714 02 CSE 5225 Advanced Pattern Recognition	●	●		●	●	●		
0714 02 CSE 5227 Knowledge Representation and Reasoning	●	●		●	●	●		●
0714 02 CSE 5229 Data Mining and Warehousing	●	●	●	●	●	●	●	●
0714 02 CSE 5231 Network Optimization	●	●		●	●		●	●
0714 02 CSE 5233 Human-Computer Interaction	●	●	●		●	●		●
0714 02 CSE 5235	●	●		●	●	●		●

Computational Imaging								
0714 02 CSE 5237 Parallel Algorithms	●	●		●				
0714 02 CSE 5239 Big Data Analytics	●	●	●	●	●	●		●
0714 02 CSE 5241 Distributed Databases	●	●		●	●	●		●
0714 02 CSE 5243 Advanced Microprocessors and Embedded System	●	●			●			
0714 02 CSE 5245 Advanced Computer Architecture	●	●			●			
0714 02 CSE 5250 Dissertation Part-I-M	●	●	●	●	●	●	●	●
Second Year First Term								
0714 02 CSE 6150 Dissertation Part-II-M	●	●	●	●	●	●	●	●
0714 02 CSE 6130 Project	●	●	●	●	●	●	●	●
0714 02 CSE 6140 Internship	●	●	●	●	●	●	●	●

OUTCOME-BASED CURRICULUM

PART-B

17. Structure of the Curriculum

a) Duration of the Program	Mixed Mode(Dissertation)	1.5 Years (3 Terms)
	Mixed Mode(Project)	1.5 Years (3 Terms)
	Mixed Mode (Internship)	1.5 Years (3 Terms)
b) Admission Requirements	Bachelor in CSE/EEE/ECE/CS/IT/ICT/related subject with a minimum GPA of 2.50 out of 4.00. The admission committee of the program may frame other specific requirements for admission.	
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program	Mixed Mode(Dissertation)	40
	Mixed Mode(Project)	41
	Mixed Mode(Internship)	41
c2) Available Credits	Mixed Mode(Dissertation)	154
	Mixed Mode(Project)	145
	Mixed Mode(Internship)	145
d) Total Class Weeks in a Term*	14	
e) Minimum CGPA Requirements for Graduation	2.50	
f) Maximum Academic Years of Completion	3.0 Years (6 Terms)	

* Term Duration				
Teaching and Learning	Preparatory Leave	Term Final Examination	Term Break	Total
14 Weeks	2 Weeks	4 Weeks	2 Weeks	22 Weeks

g1) Area-wise Credit Distribution

Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GED) Courses**	Theory	01	3.00	5.00
	Sessional	01	2.00	
Optional/Elective Courses (Theory)	Mixed Mode (Dissertation)	05	15.00	15.00
	Mixed Mode (Project)	10	30.00	30.00
	Mixed Mode (Internship)	10	30.00	30.00
Capstone Courses***	Mixed Mode (Dissertation)	02	20.00	20.00
	Mixed Mode (Project)	01	6.00	6.00
	Mixed Mode (Internship)	01	6.00	6.00
Total	Mixed Mode (Dissertation)	09	40.00	40.00 (out of 154)
	Mixed Mode (Project)	13	41.00	41.00 (out of 145)
	Mixed Mode (Internship)	13	41.00	41.00 (out of 145)

**12.5%from GED courses

*** Thesis, project, internship, etc. courses

g2) Category of Courses

Area	Course Type	Course Title		Credits
General Education (GED) Courses	Theory	01. Research Methodology and Ethics		3.00
	Sessional	01. Seminar		2.00
Core/ Compulsory Courses	Theory	-		-
	Sessional	-		-
Optional/ Elective Courses	Theory	Mixed Mode (Dissertation)	Any five (05) offered courses	15.00
		Mixed Mode (Project)	Any ten (10) offered courses	30.00
		Mixed Mode (Internship)	Any ten (10) offered courses	30.00
Capstone Courses	Dissertation/ Project	Mixed Mode (Dissertation)	Dissertation Part-I-M Dissertation Part-II-M	20.00
		Mixed Mode (Project)	Masters Project	6.00
		Mixed Mode (Internship)	Masters Internship	6.00
Total	Mixed Mode (Dissertation)			40.00
	Mixed Mode (Project)			41.00
	Mixed Mode (Internship)			41.00

18. Year/Term-wise Distribution of Courses

First Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0111 02 Edu 5151	Research Methodology and Ethics	Core	3.00	-	3.00	None
0111 02 Edu 5152	Seminar	Core	-	3.00	2.00	None
0714 02 CSE 5101	Advanced Probability and Statistics	Optional/Elective	3.00		3.00	None
0714 02 CSE 5103	Graph Theory	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5105	Advanced Bioinformatics	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5107	Advanced Numerical Analysis	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5109	Advanced Software Engineering	Optional/Elective	3.00		3.00	None
0714 02 CSE 5111	Software Testing and Quality Assurance	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5113	Computer Communications and Networks	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5115	Advanced Cloud Computing	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5117	Advanced Internet of Things	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5119	Petri Net Theory and Modeling of Systems	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5121	Advanced Machine Learning	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5123	Evolutionary Algorithms	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5125	Neural Networks	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5127	Statistical Natural Language Processing	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5129	Multimedia Systems and	Optional/Elective	3.00	-	3.00	None

	Communications					
0714 02 CSE 5131	Computer Graphics and Animation	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5133	Advanced Computer Vision	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5135	Ubiquitous Computing	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5137	Advanced Logic Design	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5139	Optimization Theory	Optional/Elective	3.00	-	3.00	None
Total	Core Courses: 02 Optional Courses: 20 Theory Courses: 21 Sessional Courses: 01		63.00 66.00	3.00	65.00	

First Year Second Term

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
0714 02 CSE 5201	Advanced Algorithms	Optional/Elective	3.00		3.00	None
0714 02 CSE 5203	Computational Geometry	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5205	Control Theory	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5207	Engineering Mathematics	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5209	Queuing Theory	Optional/Elective	3.00		3.00	None
0714 02 CSE 5211	Software Evolution and Maintenance	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5213	Wireless Ad-Hoc and Sensor Networks	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5215	Future Internet	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5217	Advanced Information security	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5219	Game Theory in Wireless and Communication Network	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5221	Blockchain Technology and	Optional/Elective	3.00	-	3.00	None

	Applications					
0714 02 CSE 5223	Temporal Logic and Model Checking	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5225	Advanced Pattern Recognition	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5227	Knowledge Representation and Reasoning	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5229	Data Mining and Warehousing	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5231	Network Optimization	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5233	Human-Computer Interaction	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5235	Computational Imaging	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5237	Parallel Algorithms	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5239	Big Data Analytics	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5241	Distributed Databases	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5243	Advanced Microprocessors and Embedded System	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5245	Advanced Computer Architecture	Optional/Elective	3.00	-	3.00	None
0714 02 CSE 5250	Dissertation Part-I-M	Optional	-	7.50	5.00	
Total	Core Courses: 00 Optional Courses: 24 Theory Courses: 23 Sessional Courses: 01		69.00	7.50	74.00	
			76.50			

Second Year First Term						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0714 02 CSE 6150	Dissertation Part-II-M	Optional	-	22.50	15.00	0714 02 CSE 5250
0714 02 CSE 6130	Project	Optional	-	9.00	6.00	None
0714 02 CSE 6140	Internship	Optional	-	9.00	6.00	None
Total	Core Courses: 00 Optional Courses: 03 Theory Courses: 00 Sessional Courses: 03			40.50	27.00	
			40.50			

19. Course Description

Course Code:0111 02 Edu 5151	**Year: First**	**Term: First**
Course Title: Research Methodology and Ethics		
Course Status: GED		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to establish or advance the understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process. This course also provides fundamental concepts of engineering ethics and the relationship between technology and moral and social values.	

Course Contents		**CLOs**
Section A		
1	Nature of the research process, types of research, ethics of research: voluntary participation, anonymity and confidentiality, deceiving subjects, analysis and reporting.	1, 4
2	Research proposal, planning, purposes of research: exploration, description, explanation, 'hard-data' focus, 'soft-data' focus, conceptualization; some practical considerations: time, venue, instrument to be used etc, research team, interviewers, willingness of respondents to participate.	1, 2, 3
3	Data collection: four levels of evaluation, levels of data collection/unit of analysis, data analysis and interpretation.	2
4	Report writing: academic writing, technical writing; feedback sessions	3
Section B		
5	Introduction to morals, values and ethics, integrity, work ethic, service learning, civic virtue, respect of others.	5
6	The processes of living peacefully, caring, sharing, honesty, courage, valuing time, cooperation, commitment, empathy, Self-confidence, character, spirituality.	5, 6
7	Introduction to Yoga and meditation for professional excellence and stress management.	6, 7
8	Senses of "Engineering Ethics", variety of moral issues, types of inquiry, moral dilemmas, moral autonomy, Kohlberg's theory, Gilligan's theory, consensus of controversy, models of professional roles, theories about right action, self-interest, customs and religion, uses of ethical theories.	7

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Demonstrate knowledge of research processes (reading, evaluating, and developing);	2
	CLO2	Identify, explain, compare, and prepare the key elements of a research proposal/report;	5
	CLO3	Define and develop a possible research interest area using specific research designs;	4, 6
	CLO4	Explain the rationale for research ethics	7
	CLO5	Understand the basic perception of profession, professional ethics and various moral issues.	4, 7, 8
	CLO6	Understand various social issues and evaluate the effects of the use of technology on social culture, economic, legal, health welfare of the society.	4, 8
	CLO7	Identify and evaluate the effects of the use of technology on environment.	4, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Written Exam
CLO3	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO6	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO7	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2010. 2. Research Methods for Science, Michael P. Marder, Cambridge University Press, 1st Edition, 2011. 3. An Introduction to Scientific Research, E. Bright Wilson, Dover Publications; Rev Sub Edition, 1991.

4. Engineering, Ethics, and the Environment, P. AarneVesilind, Alastair S. Gunn, Cambridge University Press, 1998.
5. Professional Ethics and Human Values, A. Alavudeen, R. Kalil Rahman, M. Jayakumaran, Firewall Media, 2008
6. Ethics and Science: An Introduction,Adam Briggle, Carl Mitcham, Cambridge University Press, 2012

Course Code:0111 02 Edu 5152	**Year: First**	**Term: First**
Course Title: Seminar		
Course Status: GED		
Credit:2.0		
Prerequisite(s): NULL		
Rationale	This course is for providing research background to the students through reviewing research papers, writing the reports and presenting the work	

	Course Contents	**CLOs**
	Section A	
1	**Introduction:** requirements of the course, selection of areas or fields of the seminar	1
2	**Selection of topic:** The students will select a topic from the chosen area. The concern teacher will approve her/his topic.	1, 2, 3
3	**Collection of materials**: The student will collect five or Six international conference and standard journal papers. Among the collected papers at least one must be a standard (Scopus-indexed) journal paper. The students will show the collected papers to the teacher and s/he will approve them.	2, 3
4	**Study of the materials**: The teacher will explain the procedure to study the papers.	2, 3
	Section B	
5	**Writing Literature Review**: The teacher will describe how to write literature review section of the report. The students will write the literature review on the collected papers mentioning advantages and disadvantages of the works as well as the scope of the future work.	2, 3
6	**Writing comparative study:** The students will write a comparative study using the collected papers for this the concern teacher will give them guidelines.	2,3
7	**Writing introduction and conclusions:** Depending on the literature survey and comparative study the students will write these two sections.	2, 3
8	**Repot submission:** The students will complete their reports, format them in a specific format suggested by the teacher and submit the reports**.**	3, 4
9	**Presentation:** The students will prepare slides and present their work and answer the questions of the audience in the class. All the students and the concern teacher will be the audience.	4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand how to select a study area or topic and study the research papers.	1, 2
	CLO2	Collect research materials of the selected topic.	1, 2, 3

	CLO3	Understand how to write a review reports on the selected topic	2, 3, 4, 5
	CLO4	Learn formatting a report, preparation of slides and presentation	4, 5, 6

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand how to select a study area or topic and study the research papers.	1, 2
	CLO2	Collect research materials of the selected topic.	1, 2, 3
	CLO3	Understand how to write a review reports on the selected topic	2, 3, 4, 5
	CLO4	Learn formatting a report, preparation of slides and presentation	4, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Discussion, question and answer session	Quiz, Viva, and Evaluation
2	Discussion, Problem-based Learning and answer, and question session	Quiz, Viva and Evaluation
3	Discussion, Problem-based learning, submission of a report and presentation	Viva and final Assessment

Learning Materials

Recommended Readings	1. One or two review papers published in the journal(s) with impact factor or cite score.

Course Code:0714 02 CSE 5101	**Year: First**	**Term: First**
Course Title: Advanced Probability and Statistics		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course covers the fundamentals and tools for probabilistic modeling in a diverse range of Engineering fields, including communication, networking, computer systems, and signals processing.	

	Course Contents	**CLOs**
	Section A	
1	Sample Space and Probability: Sets, Probabilistic Models, Conditional Probability, Independence, Total Probability Theorem and Bayes' Rule, Counting	1
2	Discrete Random Variables: Basic Concepts, PMF, Functions of RV, Expectation, Mean, Variance, Joint PMFs of MRVs, Conditioning, Independence	2
3	General Random Variables: Continuous RVs and PDFs, CDFs, Normal RV, Conditioning on an Event, MCRV, Derived Distributions	3
	Section B	
4	Bernoulli and Poisson Processes	4
5	Markov Chains: Discrete-Time Markov Chains, Classification of States, Steady-State Behavior, Absorption Probabilities, and Expected Time of Absorption	5
6	Limit Theorems: Inequalities, Weak Law of Large Numbers, Convergence in Probability, Central Limit Theorem, Strong Law of Large Number	6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	describe the general structure of probabilistic models and their basic properties	1, 2
	CLO2	demonstrate the important concept of the random variable (discrete) and its manipulation	2, 3, 5,6
	CLO3	demonstrate the important concepts and methods of the continuous random variable	2, 3, 5,6
	CLO4	model the stochastic processes through probabilistic experiment	3, 5, 6, 8
	CLO5	analyze the probabilistic properties of the sequence of state values, which evolves over time	2, 5, 6
	CLO6	analyze the properties of random variables approximately	2, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO2	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO3	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO4	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO5	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam
CLO6	Interactive lectures, Discussions, and Problem-solving	Class Test, Presentation and Final Exam

Learning Materials

Recommended Textbook	1. D. P. Bertsekas and J. N. Tsitsiklis, "Introduction to Probability (2nd edition)", 2008. 2. Sheldon M. Ross, “Introduction to Probability Models”, 10th Edition, 2010

Course Code:071402 CSE 5103	**Year: First**	**Term: First**
Course Title: Graph Theory		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to introduce graphs as a powerful modeling tool that can be used to solve practical problems in various fields.	

	Course Contents	**CLOs**
	Section A	
1	**Basics of Graph Theory:** Structure and Basic Definition of Graph theory, methodology, proofs, basic properties of graphs, homomorphism, automorphism graphs, symmetric graphs, graph enumeration.	1,2
2	**Graph operation:** Graph operations and their symbolic designation, Orientation of graph; associated matrices and their relationships	1,2,4
3	**Coloring graphs**: Groups graph coloring, five color problem, four color conjectures, Heawood map coloring theorem, critical graphs.	2,4
4	**Graph Theoretic Algorithms:** Computer representation of a Graph, Connectedness and components, Spanning Tree, Shortest path between vertices, Planarity Testing	1,4
	Section B	
1	**Graph Theoretic Algorithms:** Computer representation of a Graph, Connectedness and components, Spanning Tree, Shortest path between vertices, Planarity Testing	1,4
2	**Tours and Matchings:** Euler and Hamilton path and circuit, NP-complete problems.	1,2
3	**Literature Review:** Recent articles in the field of Graph Theory published and presented in Journals and Conferences.	3,4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand the fundamental concepts in graph theory with a sense of some of its modern applications.	1, 2
	CLO2	Apply the abstract concepts of graph theory in modeling and solving complex computational problems in different fields of study.	5, 6
	CLO3	Understand and verify algorithms published in journals	3, 4, 5, 7
	CLO4	Present own graph theoretic algorithms orally and in writing.	3, 4, 5, 6, 7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Interactive lecturing, Discussions	Class Test Final Examination
2	Discussions Problem solving	Assignment Final Examination
3	Discussions, Cooperative learning	Viva Report Evaluation
4	Cooperative learning, Problem solving, Writing	Presentation Report Evaluation

Learning Materials

Recommended Readings	**Text Book:** Douglas B. West, "Introduction to Graph Theory", Pearson Education, 2nd edition, 2008.
Supplementary Readings	**Graph Theory Resource Links:** https://www.graphtheory.com/

Course Code:0714 02 CSE 5105	**Year: Frist**	**Term: First**
Course Title: Advanced Bioinformatics		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s):		
Rationale	This course is to introduce, acquire knowledge and practice on biological data using different advanced algorithms as well as programming techniques necessary for developing sophisticated application programs in the areas of bioinformatics and computational biology.	

Course Contents		CLOs
	Section A	
1	**Introduction:** Introduction to bioinformatics; DNA, RNA, genes, and proteins.	1, 2
2	Restriction mapping algorithm; Motif in DNA sequences, motif finding algorithms	2, 3
3	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	2, 3
4	spectrum graphs; *Combinatorial pattern matching*: Exact pattern matching, heuristic similarity search algorithms, approximate string matching,	2, 3
	Section B	

5	BLAST, FASTA	2, 3
6	*Clustering*: Microarrays, hierarchical clustering, K-means clustering, corrupted cliques problem, CAST clustering algorithm; Evolutionary trees	2, 3
7	Design and analysis of algorithms to solve different problems in bioinformatics including optimization problems in bioinformatics	3, 4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Identify the important terminologies used in designing and analysis of evolutionary algorithms.	1
	CLO2	Understand the complex problems and existing evolutionary algorithms that are the solutions to the problems.	1, 2, 3
	CLO3	Explain the evolutionary algorithms and their analyses.	2, 3, 4
	CLO4	Design and analyze new or modified evolutionary algorithms as solutions to the complex problems.	2,, 3, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

Learning Materials

Recommended Readings	1. Bioinformatics Computing, Bryan Bergeron, Prentice Hall, 1st Edition, 2002. 2. Introduction to Bioinformatics, T.K. Attwood, D.J. Parry-Smith, Pearson Education, 1st Edition, 1997. 3. An Introduction to Bioinformatics Algorithms, By Neil C. Jones, Pavel Pevzner, The MIT Press, 1st Edition, 2004. 4. Bioinformatics: A practical guide to the analysis of genes and proteins, A.D. Baxevanis and B.F.F. Ouellette (ed.), John Wiley & Sons,

	3rd edition. 2004. 5. Biological sequence analysis, Probabilistic Models of Proteins and Nucleic Acids, Richard Durbin, Sean R. Eddy, Anders Krogh, and Graeme Mitchison, Cambridge University Press, 1998.
Supplementary Readings	1. Stephen A. Krawetz, David D. Womble, Introduction to Bioinformatics, Springer, First Edition, 2003.

Course Code: 0714 02 CSE 5107	**Year: First**	**Term: First**
Course Title: Advanced Numerical Analysis		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course covers the use, implementation and analysis of efficient and reliable numerical algorithms for solving several classes of mathematical problems in computer science. This course assumes that students have done an undergraduate course in Numerical Methods.	

	Course Contents	CLOs
	Section A	
1	Linear algebra: eigenvalue problem; factoring — QR, SVD; solving banded systems; conjugate gradient method for large sparse systems of linear algebraic equations.	1, 2, 3, 4, 5
2	Approximation theory: minimax problem; continuous least squares problem.	1, 2, 3, 4, 5
3	Optimization: linear least squares — full-rank and rank deficient cases; nonlinear least squares — convergence results, Gauss-Newton, Levenberg-Marquardt method; quadratic objective function with linear constraints.	1, 2, 3, 4, 5
4	Introduction to integral equations: statement of the different types, some results about existence; Fredholm equations — finite difference, collocation; Volterra — one-step methods.	1, 2, 3, 4, 5
	Section B	**CLOs**
5	Nonlinear algebraic systems: quasi-Newton methods; approximation to the Jacobian; parameter continuation methods.	1, 2, 3, 4, 5
6	Solutions of ordinary differential equations: initial value problems; variable step size; stiff problems; two-point boundary value problems; shooting, collocation.	1, 2, 3, 4, 5
7	Fourier transforms in one dimension: DFT versus FFT; calculating FFTs.	1, 2, 3, 4, 5
8	Cubic splines.	1, 2, 3, 4, 5
9	Quadrature: globally adaptive methods.	1, 2, 3, 4, 5

	Upon completion of this course the students will be able to		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Solve examples of the types of problems covered in the course using advanced numerical methods.	1, 6, 8
	CLO2	Demonstrate how to check the accuracy of numerical solutions calculated using the methods.	1, 4, 5
	CLO3	Critique alternative methods for solving a given problem.	2, 3, 4, 5, 6, 8
	CLO4	Demonstrate the limitations of the methods.	2, 4, 5
	CLO5	Demonstrate the use of the methods in a high-level software package.	1, 4, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Problem solving and discussion	Assignments, class tests, and final examination
2	Lecture, problem-based learning and answer, and question session	Quiz, class tests, and final examination
3	Lecture, problem solving and discussion	Quiz, class tests, and final examination
4	Lecture, discussion, question and answer session	Quiz, class tests, and final examination
5	Problem-based learning and answer	Assignments, and evaluation

Learning Materials

Recommended Readings	1. Gene H. Golub and Charles F. Van Loan, *Matrix Computations*, 3rd Edition. 2. Edwin K. P. Chong and Stanislaw H. Zak, *An Introduction to Optimization*, 4th Edition. 3. Alan Oppenheim and Ronald Schafer, *Discrete-Time Signal Processing*, 3rd Edition. 4. Gary D. Knott, *Interpolating Cubic Splines*, 1st Edition.
Supplementary Readings	1. Isaac Amidror, *Mastering the Discrete Fourier Transform in One, Two or Several Dimensions: Pitfalls and Artifacts*, 2013th Edition.

Course Code:0714 02CSE 5109	**Year: First**	**Term: First**
Course Title: Advanced Software Engineering		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide knowledge and expertise on different steps of software development life cycle and software engineering tasks in order to improve learners' ability in managing and developing quality software systems.	

	Course Contents	CLOs
	Section A	
1	**Introduction to Software Engineering:** Software Lifecycle, Ethics in software engineering, Unified Modeling Language: Class diagram, Component diagram, Composite structure diagram, Deployment diagram, Object diagram, Package diagram, Profile diagram	1
2	**Requirements Engineering:** Feasibility Study, Requirement Gathering, Software Requirement Specification, Software Requirement Validation.	1
3	**Design:** Software design patterns, software design principles;	2
4	**Testing:** different types of functional and non-functional testing	3
	Section B	
5	**Refactoring:** Different refactoring techniques and their pros and cons.	2
6	**Extreme Programming:** pair programming, planning game, continuous process, coding standards, sustainable pace, test driven development	3, 4
7	**Software Architecture:** Service Oriented Architecture, Model Driven Architecture, Aspect Oriented Software Development, Software Processes.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Explain software life-cycle and professional ethics, use UML to make different diagrams such as class diagrams, component diagrams and analyze and validate the requirements obtained from the clients.	1, 6
	CLO2	Apply different design principles and patterns and refactoring techniques and tools while developing software systems.	4
	CLO3	Explain different testing techniques and apply them to ensure the quality of software systems.	3
	CLO4	Explain different software architectures and apply the related knowledge while developing software systems following a particular software engineering process.	3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
CLO2	Lecture, discussion, question and answer session	Class tests, programming assignments, final examination
CLO3	Lecture, discussion, question and answer session	Class tests, programming assignments, final examination
CLO4	Lecture, discussion, Problem Solving, Brainstorming	Class tests, programming assignments, term papers, oral and written examinations

Learning Materials

Recommended Textbook	1. Software Engineering: A Practitioner's Approach, Roger Pressman, Bruce Maxim, 8th Edition, 2014. 2. Fundamentals of Software Engineering, Carlo Ghezzi, Mehdi Jazayeri Dino Mandrioli, Prentice Hall, 2nd Edition, 2002. 3. Object Oriented Software Engineering using UML, Patterns, and Java, Bernd Bruegge, Allen H. Dutoit, Prentice Hall, 3rd Edition, 2009.

Course Code:0714 02CSE 5111	**Year: First**	**Term: First**
Course Title: Software Testing and Quality Assurance		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course aims to provide advanced knowledge on the state-of-the-art software testing tools, techniques, strategies and research towards ensuring software quality.	

	Course Contents	CLOs
	Section A	
1	**Definition and concept of software quality assurance (SQA):** quality models; specification of quality requirements; product development & delivery issues; software development processes & maturity;	1
2	**Software quality management process:** Total quality management, improvement cycle, SQA planning & management, organizing the SQA effort; software verification & validation; typical software development errors; Fagan inspections; software audit;	2
	Section B	
3	**Fundamentals of software testing:** testing objectives & testing fundamentals, testing theory, coverage criteria, equivalence class testing, value-based testing, decision table, syntax & state transition testing, statement & path testing, branch & condition testing,	3
4	**Software testing:** data flow testing, thread-based testing, integration & integration testing, system testing; testing in object-oriented	3

	systems; test tools & test automation; test management; problem reporting & corrective action.	

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Explain different quality models and use them for assuring software quality.	3
	CLO2	Apply their knowledge on software quality management process for managing total quality, SQA planning, and organizing SQA team effort.	5
	CLO3	Explain different testing techniques and tools and apply them to ensure software quality at different stages of SDLC.	4

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, discussion, question and answer session	Class tests, quiz,, final examination
3	Lecture, discussion, question and answer session	Class tests, programming assignments, final examination

Learning Materials

Recommended Textbook	1. Foundations of Software Testing, Aditya P. Mathur, Addison-Wesley Professional, 2nd Edition, 2014. 2. Software Testing: Principles and Practices, Srinivasan Desikan, Gopalaswamy Ramesh, Pearson Education, 1st Edition, 2006. 3. Handbook of Software Quality Assurance, G. Gordon Schulmeyer, Artech House Publishers, 4th Edition, 2007.

Course Code:0714 02 CSE 5113	**Year: First**	**Term: First**
Course Title: Computer Communications and Networks		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	The goal of this course is to expose students to modern and fundamental developments in computer communication and network systems	

	Course Contents	CLOs
	Section A	
1	Modifications of TCP; TCP over ATM; ATM internetworking; ATM service categories and quality of services; ATM switch architectures	1

	and their performance	
2	Digital switching; Traffic analysis; Fiber optics networks optical packet switching, IP switching: Tag switching, Multi-protocol label switching;	2
3	Metropolitan networks, Wide area networking, Gigabit Ethernet, ADSL	3
	Section B	
4	HTTP, pHTTP and recent advances in internet protocols; Web server performance, proxy servers, load balancing in web servers;	4
5	Queuing models for networks and protocols; Real time protocols: RTP, RTCP, RTSP; Voice over IP	5
6	Distributed object technology for networking; Networks agents; Active networks and protocol boosters	6
7	Multimedia Networking: Integrated Service, Differential Service, MPLS	7

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	understand the fundamental concepts of TCP and ATM and its development	1, 2
	CLO2	Conceptualize switching system	2, 5, 6, 8
	CLO3	Understand the concepts of different networks	1, 2
	CLO4	Understand the concepts of web services	2, 5, 6, 8
	CLO5	Understand the concepts of different queuing model used in network	1, 2, 8
	CLO6	Understand the objects used in networking system	5, 6
	CLO7	Conceptualize multimedia service in networks	2, 5,6 ,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO6	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO7	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Data and Computer Communications, William Stallings, Prentice Hall, 10th Edition, 2013. 2. Computer Networks, Andrew S. Tanenbaum, Prentice Hall, 5th Edition, 2010. 3. Computer Networks and Internets, Douglas E Comer, Addison-Wesley, 6th Edition, 2014.

Course Code:0714 02 CSE 5115	**Year: First**	**Term: First**
Course Title: Advanced Cloud Computing		
Course Status: Optional/Elective		
Credit:		
Prerequisite(s): None		
Rationale	Students completing Advanced Cloud Computing will develop a broad based understanding of state-of-the-art technologies, underlying business and technological trends, key systems and artifacts and research directions in modern data center computing, scalable distributed systems, and programming frameworks enabling the widespread adoption of cloud computing. Many will go on to code, design and architect innovative new cloud computing services and offerings, and to develop business processes to exploit opportunities afforded by modern cloud computing.	

	Course Contents	**CLOs**
	Section A	
1	Introduction to Cloud Computing	1
2	Foundations: Containers, Virtual Machine, JVM	
3	MAAS, PAAS, Web Services	
4	Storage: Ceph, SWIFT, HDFS, NAAS, SAN, Zookeeper	
5	Cloud Computing (Cloud Storage, Computation, Databases, Security,etc)	2
6	Architecting Cloud Solutions.	
	Section B	
7	DevOps tools and practices on Cloud.	1, 3
8	IOT on Cloud.	
9	Containers in Cloud & Cloud Migration.	
10	Managing Cloud Solutions and Migrating to Cloud	

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Describe, explain, justify, and criticize differing perspectives on the definition, novelty, and essential features of state of the art cloud computing.	1,3
	CLO2	Design and implement distributed systems for big data science applications to operate in and exploit advanced features of cloud computing systems.	1,2,3
	CLO3	Design, criticize, implement and improve features of large scale cluster computing, with emphasis on scale elasticity, limitations on unusually long duration	5,7

		corner cases, high availability in the face of rare and dependent failure modes.	
	CLO4	Interpret and criticize cloud computing research papers, and anticipate and design strategies to avert structural or implementation problems identified.	1,2,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing, Discussions, Problem solving	Quiz Class Test
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Assignment Class Test
CLO3	Interactive lecturing, Discussions, Industry Grade Project	Assignment Class Test
CLO4	Presentations	Group Study Final Project Presentations

Learning Materials

Recommended Readings	**Text Book:** Advances in Big Data and Cloud Computing Authors: Elijah Blessing Rajsingh (Editor), JeyVeerasamy (Editor), Amir H. Alavi (Editor), J. Dinesh Peter (Editor) Publisher: Springer; 1st ed. 2018 edition (April 7, 2018) ISBN: 9811071993
Supplementary Readings	**Reference Book:** 1. **AWS: Amazon Web Services, the Ultimate Guide for Beginners to Advanced** Authors: Maverick Koston Publisher: Independently published (January 21, 2020) ISBN: 979-8602273953 2. **Advance Cloud Computing** Authors: Yashpal Singh (Author), Dr. K. Reddy Madhavi (Author), Navnath D Kale (Editor) Publisher: LAP LAMBERT Academic Publishing (November 1, 2018) ISBN: 6139943116

Course Code:0714 02 CSE 5117	**Year: First**	**Term: First**
Course Title: Advanced Internet of Things		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide required foundations about the Internet of Things (IoT), how heterogeneous devices communicate and/or store relevant data.	

	Course Contents	**CLOs**
	Section A	
1	Architectural formation and communication models	1
2	RFID Technology, Wireless sensor networks, Communication technologies	2
3	Cloud Computing, Middleware and Big Data	2
	Section B	
4	HTTP, UPnP, CoAP, MQTT protocols	3
5	Applications on Smart Cities, Industrial Internet of Things (IIoT), Smart Grids, Smart Homes, Smart Agriculture, Smart Health, Smart Mobility, Smart Environment	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Describe IoT architectural formation and communication models.	1, 2, 4, 5, 8
	CLO2	Describe IoT technologies RFID, WSN, Cloud Computing, Big Data, Middleware.	1, 2, 4, 5, 8
	CLO3	Describe HTTP, UPnP, CoAP, MQTT protocols.	1, 2, 4, 5, 6, 8
	CLO4	Analyze IoT applications on Smart Cities, Industrial Internet of Things (IIoT), Smart Grids, Smart Homes, Smart Agriculture, Smart Health, Smart Mobility, Smart Environment, etc.	1, 2, 3, 4, 5, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture, presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	1. Learning Internet of Things, Peter Waher, PACKT Publishing, 2015 2. Distributed and Cloud Computing, Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, Elsevier, 2012 3. Internet of Things and Data Analytics Handbook, HwaiyuGeng, John Wiley & Sons, 2017. 4. Principles of Internet of Things (IoT) Ecosystem: Insight Paradigm, Sheng-Lung Peng, Souvik Pal, Lianfen Huang, Springer, Intelligent Systems Reference Library, Volume 174.

Course Code: 0714 02 CSE 5119	**Year: First**	**Term: First**
Course Title: Petri Net Theory and Modeling of Systems		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed such that the students can represent and analyze concurrency and synchronization phenomena of different distributed systems in an easy way and formalize model checking of the model of those systems.	

	Course Contents	**CLOs**
	Section A	
1	Introduction to Petri nets, basic notions.	1,2
2	Condition/Event (C/E) Petri nets.	2,3
3	Complementation, case graphs, and applications in C/E systems analysis.	3
4	Processes of C/E Petri nets, occurrences nets.	3,4
5	Properties of C/E Petri nets, synchronic distances, facts.	5,6
6	Place/Transition (P/T) Petri nets, analysis problems.	4
	Section B	
7	Analysis of P/T Petri nets by reachability tree.	2, 3
8	Invariants of P/T Petri nets.	4
9	Petri nets languages.	5, 6
10	Marked graphs and Free choices Petri nets, Petri nets with inhibitors.	1, 3
11	Coloured Petri nets, CPN Design, applications.	2, 4
12	Analysis of Coloured Petri nets.	5,6
13	Hierarchical Coloured Petri nets and Object oriented Petri nets.	6
14	Introduction to model checking	6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	understand the basic concepts and methods of system modelling using Petri nets	1, 2
	CLO2	adopt the Petri nets theory and applications in problems of system modelling, design, and verification	1, 2

	CLO3	gain practical experiences with representative Perti nets tools	4, 5
	CLO4	apply Petri nets and supporting tools in system modelling, design, and verification	5, 6
	CLO5	apply and develop advanced information technologies based on suitable formal models	2, 6
	CLO6	propose and use such models and theories for automating the design, implementation, and verification of computer-based systems	1, 2, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO2	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO3	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO4	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO5	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO6	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Petri Net Theory and the Modeling of Systems, By James Lyle Peterson 2. Understanding Petri Nets: Modeling Techniques, Analysis Methods, Case Studies, By Wolfgang Reisig 3. Petri nets: Properties, analysis and applications, By Tadao Murata

Course Code: 0714 02 CSE 5121	**Year: First**	**Term: First**
Course Title: Advanced Machine Learning		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is designed to provide the students with knowledge needed to understand the techniques for designing analytical systems using machine learning algorithms. This course covers the methodologies, technologies, and algorithms of machine learning from a variety of perspectives. Topics includes Definition of learning systems, Goals and applications of machine learning, Inductive Classification, Various learning techniques, Experimental Evaluation of Learning Algorithms, Text Classification, Language Learning, etc.	

Course Contents		CLOs
1	Definition of learning systems	1
2	Goals and applications of machine learning	1
3	Inductive Classification	2,3,4
4	Decision Tree Learning	3,4
5	Ensemble Learning	3,4
6	Experimental Evaluation of Learning Algorithms	2,3
7	Computational Learning Theory	2,3
	Section B	
8	Rule Learning: Propositional and First-Order	3,4
9	Artificial Neural Networks	3,4
10	Support Vector Machines	3,4
11	Bayesian Learning	3,4
12	Instance-Based Learning	3,4
13	Text Classification	2,3,4
14	Clustering and Unsupervised Learning	3,4
15	Language Learning	2,3,4

	Upon completion of this course the students will be able to		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand Basic concepts of Machine Learning	1
	CLO2	Infer advanced machine learning theories	2, 5
	CLO3	Apply machine learning techniques in practical problems.	2, 3, 4, 6
	CLO4	Gain knowledge about state-of-the-art algorithms used in machine learning research.	2, 3, 4, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning, question and answer session	Quiz, Class tests, and written examination
3	Problem Solving, Brain Storming	Assignments, Assessment and final examination
4	Lecture, problem- based learning and presentation	Assignments, Term papers, Oral and written examinations

Learning Materials

Recommended Readings	1. Genetic Algorithms in Search, Optimization & Machine Learning, David E. Gold Berg, Addison-Wesley Professional, 1st Edition, 1989. 2. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 2007. 3. Machine Learning: An Artificial Intelligence Approach, Volume 2, edited by Ryszard S. Michalski, Ryszard Stanisław Michalski, Jaime Guillermo Carbonell, Tom Michael Mitchel, Morgan Kaufmann, 1982.
Supplementary Readings	

Course Code:0714 02 CSE 5123	**Year: First**	**Term: First**
Course Title: Evolutionary Algorithms		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s):		
Rationale	This course is to introduce, acquire knowledge and practice on evolutionary algorithms as well as programming techniques necessary for developing sophisticated application programs in the areas of bioinformatics, system design, telecommunication, robotics and other industrial areas.	

Course Contents		**CLOs**
Section A		
1	**Introduction:** Introduction to evolutionary algorithm, optimization, heuristics and meta-heuristics.	1, 2
2	**Selection:** rank-based, roulette wheel, stochastic, local, truncation and tournament;	2, 3
3	**Recombination**: discrete, real valued and binary valued	2, 3
4	**Mutation**: real valued and binary valued, **Reinsertion**: global and local	2, 3
5	**Population models**: global- worker/farmer, local – diffusion, and regional – migration;	2, 3
6	**Co-evolution**: cooperative and competitive; Learnable evolution model; Fast evolutionary programming.	2, 3
7	**Application of evolutionary algorithms to**: bioinformatics, system design, telecommunication, robotics and other industrial areas.	4

Course Learning Outcomes	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Identify the important terminologies used in designing and analysis of evolutionary	1

(CLOs)		algorithms.	
	CLO2	Understand the complex problems and existing evolutionary algorithms that are the solutions to the problems.	1, 2, 3
	CLO3	Explain the evolutinary algorithms and their analyses.	2, 3, 4
	CLO4	Design and analyze new or modified evolutionary algorithms as solutions to the complex problems.	2,, 3, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

Learning Materials

Recommended Readings	1. Introduction to Evolutionary Algorithms, X Yu, M Gen, Springer London, 1 Edition, 2010 2. Evolutionary Algorithms in Engineering Applications, edited by Dipankar Dasgupta, Zbigniew Michalewicz, Springer, 1997. 3. Evolutionary Algorithms for Solving Multi-Objective Problems, Carlos Coello Coello, Gary B. Lamont, David A. van Veldhuizen, Springer, 2nd Edition, 2007. 4. Multi-Objective Optimization Using Evolutionary Algorithms, Kalyanmoy Deb, Wiley Publishers, 1st Edition, 2009.
Supplementary Readings	1. Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest, Introduction to Algorithms, Third Edition or Later, Prentice-Hall;

Course Code:0714 02 CSE 5125	**Year: First**	**Term: First**
Course Title: Neural Networks		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		

Rationale	This course introduces the basics of Neural Networks and essentials of Artificial Neural Networks with Single Layer and Multilayer Feed Forward Networks. This subject is very important and useful for solving complicated practical problems such as robotic control, data mining and recognition.

Course Contents		**CLOs**
Section A		
1	Fundamentals of Neural Networks, Back propagation and related training algorithms.	1
2	Hebbian learning; Cohonen-Grossberg learning; The BAM and the Hopfield Memory, Simulated Annealing.	2
3	Different types of Neural Networks: Counter propagation, Probabilistic, Radial Basis Function, Generalized Regression	1, 2
4	Application of Neural Networks.	3
Section B		
5	Adaptive Resonance Theory; Dynamic Systems and neural Control; The Boltzmann Machine;	2, 4
6	Self-organizing Maps; Spatiotemporal Pattern Classification, The Neocognition; Practical Aspects of Neural Networks.	2, 3, 4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	To remember and understand the internal mechanism of neural network.	1, 2
	CLO2	To demonstrate the deep understanding on various dynamics of systems based on neural network architecture.	2, 3, 4
	CLO3	To apply the knowledge for designing solutions for real-world problems.	4, 5, 6
	CLO4	To analyze and evaluate the optimization requirement.	2, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Quiz, Class tests, and written examination
CLO2	Lecture, Presentation, question and answer session	Quiz, Class tests, and written examination
CLO3	Lecture, Presentation, and Group Discussion	Quiz, Class tests, and written examination
CLO4	Lecture, Presentation and Problem Solving	Quiz, Class tests, and written examination

Learning Materials

Recommended Textbook	1. Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence/Book and Disk, Bart Kosko, Prentice Hall, Har/Dis Edition, 1991. 2. Fundamentals of Artificial Neural Networks, Mohamad H. Hassoun, A Bradford Book, 2003.

	3. Understanding Neural Networks and Fuzzy Logic, Stamatios V. Kartalopoulos, Wiley-IEEE Press, 1st Edition, 1995.

Course Code:0714 02 CSE 5127	**Year: First**	**Term: First**
Course Title: Statistical Natural Language Processing		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide advanced knowledge and expertise on the field of natural language processing and related application analysis.	

Course Contents		**CLOs**
Section A		
1	Introduction to natural language processing, regular expressions, and CFGs for English. Introduction to statistical natural language processing.	1
2	Morphology, Tokenization, and FSA, Phonetics, Phonology and text-to-speech, speech-to-text	1, 2
3	Corpus based work, Collocations	2, 3
4	Statistical Inference: N-gram model, Smoothing and Discounting, Neural Network models, Machine Learning.	2, 3
Section B		**CLOs**
5	Parts-of-Speech Tagging: Hidden Markov Model, Viterbi Algorithm	4
6	Meaning representations and semantic analysis, Lexical semantics, Word sense disambiguation	2, 3, 4
7	Text Categorization, Text Clustering	2, 3, 4
8	Information Retrieval, Neural Information Retrieval, Latent Semantic Indexing and Probabilistic Retrieval	4

	Upon completion of this course the students will be able to		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Remember and understand the concepts of natural language processing	1, 2, 8
	CLO2	Apply methods to compute understanding from text, ranging from formal logic to neural word embeddings	1, 2, 6, 8
	CLO3	Apply syntax and semantical language processing techniques	1, 2, 6, 8
	CLO4	Apply, analyze and evaluate tools and techniques of text-to-speech, speech-to-text, text summarization, text categorization, text clustering and information retrieval applications.	1, 2, 3, 4, 5, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and

		Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture, presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Readings	1. Daniel Jurafsky, James H. Martin,"Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Prentice Hall, 1st edition, 2000. 2. Christopher D. Manning, Hinrich Schtze,"Foundations of Statistical Natural Language Processing", The MIT Press; 1st edition, 1999. 3. Jacob Eisenstein "Introduction to Natural Language Processing", MIT Press Ltd; 1st edition, 2019

Course Code: 0714 02 CSE 5129	**Year: First**	**Term: First**
Course Title: Multimedia Systems and Communications		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is designed to provide the students with knowledge needed to understand multimedia information representation and multimedia communication across networks. Students acquire knowledge about multimedia systems , multimedia database and multimedia applications, image encoding , audio encoding, video encoding , multimedia communication across networks multimedia in mobile networks and multimedia broadcast networks.	

Course Contents		**CLOs**
Section A		
1	Overview to Multimedia Systems	1
2	Multimedia storage and multimedia database	1,5
3	Multimedia data, multimedia networking and protocols	1,3,5
4	Image encoding	1,4,5
5	Audio encoding	1,4,5
6	Video encoding	1,4,5
Section B		
7	Multimedia information representation	1,5
8	Multimedia networks, Multimedia services and applications	1,3,5
9	Text and image compression	1,2,5
10	Audio and Video compression	1,2,5
11	Multimedia compression standards	1,2,5
12	Multimedia communication across networks	1,3,5

Course	Upon completion of this course the students	**Mapping with**

Learning Outcomes (CLOs)	will be able to		**PLOs**
	CLO1	Understand multimedia systems and applications	1, 2, 5, 6
	CLO2	Understand and able to apply methods and techniques for data compression, image , audio and video compression	1, 2, 5, 6, 8
	CLO3	Understand the broad concepts of multimedia communication across networks	1, 2, 5, 6
	CLO4	Understand the basic concepts of text image , audio and video encoding	1, 4, 5, 6, 8
	CLO5	Able to apply methods and techniques for multimedia services and applications	2, 4, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming	Assignments, Term papers, Oral and written examinations
5	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination

Learning Materials

Recommended Readings	1. Multimedia Systems, Ralf Steinmetz, Klara Nahrstedt, Springer Berlin Heidelberg, 2010. 2. Introduction to Multimedia Systems, Urbashi Mitra, Academic Press, 2004. 3. Multimedia Communications, Jerry D. Gibson, Academic Press, 2000. 4. Multimedia Communication Systems: Techniques, Standards, and Networks, K.R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, Prentice Hall, 1st Edition, 2002.
Supplementary Readings	1. Multimedia Systems, John F. Koegel Buford, Addison-Wesley Professional, 1994.

Course Code:0714 02 CSE 5131	**Year: First**	**Term: First**

Course Title: Computer Graphics and Animation

Course Status: Optional/Elective

Credit:3.00

Prerequisite(s): None

Rationale	This course is designed to focus on some advanced techniques used in computer graphics and animation systems and to explore the state-of-the-art methods of these systems.

Course Contents		CLOs
Section A		
1	**Introduction to Computer Graphics:** Graphics basics, Two and three dimensional geometry, Vectors in graphics, Representation and modeling of three dimensional objects, Polygonal representation, Parametric representation.	1
2	**Advanced Graphic Techniques:** Three dimensional drawings, Geometric forms and models, Hidden surfaces, Fractals.	1, 2
3	**Graphics Software:** A simple graphic package, Segmented display files, Geometric models, Picture structure.	2
4	**Advanced Rendering Techniques:** Shadow generation techniques, Texture and environment mapping techniques, Procedural texture mapping and modeling, Ray tracing, Radiosity methods, Global illumination models, Volume rendering techniques.	1, 2
Section B		
1	**Basics of Animation:** Principles of Animation, Key framing, Deformations, Character Animation, Physics-Based Animation.	3
2	**Graphics Animation:** Real time graphics, Graphics display and updates, Key framing systems, Motion specification.	3, 4
3	**Advanced Animation:** Animation articulated structures, Soft object animation, Procedural animation, Groups of objects.	3, 4
4	**Computer Animation:** State-of-the-art and the Future.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Illustrate the basic structure of modern computer graphics systems.	1, 5
	CLO2	Explain the advanced techniques of implementing computer graphics primitives.	2, 4, 6
	CLO3	Understand the theory and techniques involved in the creation of digital animation.	1, 6
	CLO4	Develop a variety of animation techniques and apply them for animating articulated figures and actual animation production.	2, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination
4	Interactive lecturing, Discussions, Problem solving	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Readings	TextBook(s): 1. Fundamentals of Computer Graphics, Steve Marschner, Peter Shirley, CRC press, 4th Edition, 2016 2. Computer Graphics Principle and Practice, D. Hearn and M. P. Baker, Addison-Wesley Professional, 3rd Edition, 2013. 3. Computer Graphics Multimedia and Animation, Malay K. Pakhira, PHI Learning, 2010. 4. Computer Graphics with OpenGL, Donald D. Hearn, M. Pauline Baker, Prentice Hall, 3rd Edition, 2003.
Supplementary Readings	1. http://www.cs.ubc.ca/~van/sca/sca.html 2. http://www.motioningames.org/

Course Code:0714 02 CSE 5133	**Year: First**	**Term: First**

Course Title: Advanced Computer Vision

Course Status: Optional/Elective

Credit:

Prerequisite(s): None

Rationale	Provide an overview of the challenges of vision, the common approaches and current techniques. While specific examples and applications may be used to illustrate, the focus will be on fundamental techniques and algorithms.

Course Contents		**CLOs**
Section A		
1	Background, requirements and issues, human vision	1
2	Image formation: geometry and photometry: Geometry, photometry (brightness and color), quantization, camera calibration	
3	Image segmentation and Feature Extraction: Various methods of image segmentation, edge detection, object proposals, SIFT features	
4	Multi-view Geometry: Shape from stereo and motion, feature matching, surface fitting, Active ranging	
5	Object Recognition: Traditional Methods: HoG/SIFT features, Bayes classifiers, SVM classifiers	2,3
Section B		
6	Introduction to Neural Networks: Artificial neural networks, loss functions, backpropagation and SGD, Batch Normalization	
7	Object Recognition: Deep Learning Methods: Image classification, object detection and semantic segmentation, adversarial attacks. Various neural network architectures, visualization techniques.	1, 2
8	Motion analysis and Activity Recognition: Motion detection and tracking, Inference of human activity from image sequences	
9	Selected Topics: Examples: Face recognition, Image grounding, Visual question answering	

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Provide a brief idea of Image segmentation and Feature Extraction	1,2,4,5
	CLO2	Analysis and develop using image segmentation, edge detection, object proposals, SIFT features.	1,2
	CLO3	Explain the and highlight knowledge on different techniques like Object Recognition and Multi-view Geometry	4,5,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Interactive lecturing, Discussions, Problem solving	Quiz Class Test
CLO2	Interactive lecturing, Visualization,	Assignment

	Discussions, Cooperative learning	Class Test
CLO3	Presentations	Group Study Final Project Presentations

Learning Materials

Recommended Readings	**Text Book:** "Computer Vision: A Modern Approach", D. Forsyth and J. Ponce, 2010.
Supplementary Readings	**Reference Book:** 1. Advanced Methods and Deep Learning in Computer Vision Authors: E. R. Davies, Matthew Turk Publisher: Elsevier Science, 2021 ISBN: 0128221496 2. Advanced Topics in Computer Vision Authors: Giovanni Maria Farinella, Sebastiano Battiato, Roberto Cipolla Publisher: Springer Science & Business Media, 2013 ISBN: 1447155203

Course Code:0714 02 CSE 5135	**Year: First**	**Term: First**
Course Title: Ubiquitous Computing		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide data mining related understanding, knowledge and experience so that senior students of computer science and engineering can apply advanced data analysis techniques on large datasets to evaluate real life data mining applications.	

Course Contents		**CLOs**
Section A		
1	Introduction to Ubiquitous Computing; Ubiquitous Computing Visionaries: mouse, Parc, MIT; Ethics; Privacy; Responsibility;	1
2	Architecture: Cloud Computing, Distributed Computing, Edge computing, Fog Computing, Peer to Peer;	2
3	Communication Technology: WiFi, Bluetooth, Zigbee, NFC	3
4	Radio Frequency Identification: Tag types, Applications, Standard and specifications.	4
Section B		**CLOs**
5	Wearable Computing: PAN, BAN; Service-Orientation; Sensors and Actuators; Ubiquitous environments; Context Awareness: GPS, location and tracking;	5

6	Ubiquitous theory: Location, Spatial Databases, Topological Reasoning, Metadata, Security and Privacy; Ambient Calculus; Relational Models;	6
7	Specifications: UML, OMG, Ontologies;	6
8	Applications: Smart Homes, Smart Workplaces, Social Computing, Religious Computing, Health and Medical Computing, Science, Surveillance, Monitoring, Navigation	7

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Describe ubiquitous computing and its evolution history	1, 2, 8
	CLO2	Describe ubicomp architectural models.	1, 2, 8
	CLO3	Describe communication technologies.	1, 2, 8
	CLO4	Describe device identification, RFID, tag types, standards.	1, 2, 8
	CLO5	Describe service orientation, sensors, actuators, context awareness.	1, 2, 8
	CLO6	Describe ubiquitous theory and specifications.	1, 2, 5, 6, 8
	CLO7	Evaluate real-life ubicomp applications.	1, 2, 3, 4, 5, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO5	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO6	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO7	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	1. Ubiquitous Computing Fundamentals, edited by John Krumm, Chapman and Hall/CRC, 1st Edition, 2009. 2. Ubiquitous Computing: Smart Devices, Environments and Interactions, Stefan Poslad, Wiley, 1st Edition, 2009.

	3. Everyware: The Dawning Age of Ubiquitous Computing, Adam Greenfield, New Riders Publishing, 1st Edition, 2006 4. Communication Systems Engineering, Proakis, J. G., and M. Salehi, 3rd Edition, Englewood Cliffs, NJ: Prentice-Hall, 2004.

Course Code:0714 02 CSE 5137	**Year: First**	**Term: First**
Course Title: Advanced Logic Design		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to cover advanced topics in digital design, with a special emphasis on how to model, simulate, synthesize and optimize large and complex subsystems and to seamlessly cover some of the practical industrial aspects of modern design.	

Course Contents		**CLOs**
Section A		
1	Functional decomposition and Symmetric functions	1, 2
2	Linear sequential machines	1, 2
3	Reed-Muller expansions and their minimizations	3
4	EXOR based logic design	2,3
5	Self-timed circuits	1,3
6	Asynchronous design techniques	4
Section B		**CLOs**
7	Digital logic circuit testing and testable design: testing of combinational and sequential logic circuits	1, 2,4
8	Design for testability and built-in self test	1, 2, 3
9	Digital logic simulation	1, 2, 3
10	Reverse logic synthesis	2, 3, 4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	gain knowledge of the data structures and algorithms used in modern logic synthesis tools	1, 2
	CLO2	learn advanced techniques for logic circuit optimization	2, 5
	CLO3	develop skills in evaluating different data structures for target applications	5, 6
	CLO4	understand merits and limitations of logic synthesis	1, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO2	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO3	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO4	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Advanced Digital Logic Design: Using Verilog, State Machines, and Synthesis for FPGAs, Sunggu Lee, Thomson, 2006. 2. Switching Theory and Logic Design, C V S Rao, Pearson Education, 2006. 3. Advanced Digital Logic Design: Using Verilog, State Machines, and Synthesis for FPGAs Sunggu Lee, Cengage Learning, 1st Edition, 2005. 4. Digital Logic Design, Brian Holdsworth, Clive Woods, Newnes, 4th Edition, 2002.

Course Code:0714 02 CSE 5139	**Year: First**	**Term: First**
Course Title: Optimization Theory		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	The goal of this course is to expose students to modern and fundamental developments in convex optimization, a subject which has experienced tremendous growth in the last 15 years or so	

	Course Contents	CLOs
	Section A	
1	Introduction, Convex Function, and Convex Sets	1
2	Convex Optimization and Lagrange Duality	2
3	Linear and Quadratic Programming	3
4	Unconstrained Optimization Algorithms	4
	Section B	
5	Constrained Optimization Algorithms	4
6	Geometric Programming	5
7	Primal and Dual Decomposition: Theory and Distributed Algorithms	6
8	Branch and Bound Algorithm	7

Course Learning	Upon completion of this course the students will be able to:	**Mapping with PLOs**

Outcomes (CLOs)	CLO1	understand the fundamental concepts of mathematical optimization	1, 2
	CLO2	Conceptualize and manipulate of convex optimization	2, 5, 6
	CLO3	Understand the concepts of linear and quadratic programming	1, 2
	CLO4	Formulate and manipulate unconstrained and constrained optimization problem	2, 5, 6
	CLO5	Understand the concepts of geometric programming	1, 2
	CLO6	Understand the solution process of optimization problem	5, 6, 8
	CLO7	Utilize branch and bound algorithm to solve optimization problems	5,6 ,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO6	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO7	Interactive lecture, Discussions, Home Work	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Stephen Boyd and LievenVandenberghe, "Convex Optimization", Cambridge University Press 2004.

Course Code:0714 02 CSE 5201	**Year: First**	**Term: Second**
Course Title: Advanced Algorithms		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): NULL		
Rationale	This course is to introduce and practice advanced algorithms and programming techniques necessary for developing sophisticated computer application programs. To get accustomed with various programming constructs such as divide-and-conquer, backtracking, dynamic programming, branch and bound, heuristics and meta-heuristics. To learn new techniques for solving specific problems more efficiently and for analyzing space and time requirements.	

Course Contents		CLOs
	Section A	
1	**Introduction:** Review of order notations and growth of functions, recurrences, probability distributions, master theorem, and analysis of algorithms.	1
2	**Advanced Data Structures**: AVL tress, Fibonacci Heaps, Van Emde Boas Priority Queues. Dynamic Data Structures for Graph Connectivity/Reachability.	1, 2
3	**String Matching**: Naive String Matching, Rabin-Karp algorithm, Knuth- Morris – Pratt algorithm.	2, 3
4	**Maximum Flows:** Augmenting Paths and Push-Relabel Methods. Minimum Cost Flows. Bipartite Matching.	2, 3
	Section B	
5	**Linear Programming:** Formulation of Problems as Linear Programs. Duality. Simplex, Interior Point, and Ellipsoid Algorithms.	2, 3, 4
6	**Approximation Algorithms:** One Way of Coping with NP-Hardness. Greedy Approximation Algorithms. Dynamic Programming and Weakly Polynomial-Time Algorithms. Linear Programming Relaxations. Randomized Rounding. Vertex Cover, Wiring, and TSP	2, 3, 4
7	**Online Algorithms:** Ski Rental. River Search Problem. Paging. The k-Server Problem. List Ordering and Move-to-Front.	2, 3, 4
8	**Theory of complexity:** Deterministic and non-deterministic algorithms, P and NP classes, Reducibility, NP-complete and NP-hard problems.	1,2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Identify the important terminologies used in designing and analysis of advanced algorithms.	1
	CLO2	Understand the complex problems and existing advanced algorithms that are the solutions to the problems.	1, 2, 3
	CLO3	Explain the advanced algorithms and their analyses.	2, 3, 4
	CLO4	Design and analyze new or modified algorithms as solutions to the complex problems.	2, 3, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

Learning Materials

Recommended Readings	1. Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest, Introduction to Algorithms, Third Edition or Later, Prentice-Hall; 2. Ellis Horowitz, SartajSahni, and Rajasekaran, Computer Algorithms, Galgotia publications Pvt. Ltd. 3. D E Knuth, Art of Programming, Volume 1: Fundamental Algorithms, Edison Wisely 4. D E Knuth, Art of Programming, Volume 2: Seminumerical Algorithms, Edison Wisely 5. D E Knuth Art of Programming, Volume 3: Searching and sorting, Edison Wisely 6. D E Knuth Art of Programming Volume 4: Combinatorial Algorithms, Edison Wisely
Supplementary Readings	1. Ellis Horowitz, SartajSahni, and Rajasekaran, Computer Algorithms, Galgotia publications Pvt. Ltd.

Course Code:0714 02 CSE 5203	**Year: First**	**Term: Second**
Course Title: Computational Geometry		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is concerned with the development, analysis, and computer implementation of algorithms encountered in geometric modelling.	

	Course Contents	CLOs
	Section A	
1	**Line Segment Intersection:** Thematic Map Overlay, Line sweeping algorithm, Doubly-Connected Edge List, Computing the Overlay of Two Subdivisions	1,2
2	**Geometric searching:** Point location problem and range searching	1,2,4

	problems, amortization, multi- dimensional search, space sweep, duality and randomization	
3	**Convex Hulls:** Definition of convex hull, Algorithms for computing convex hull for a given set of points, analyze the efficiency of those algorithms.	2,4
4	**Polygon Triangulation:** Art Gallery guarding problem, Guarding and Triangulations, Partitioning a Polygon into Monotone Pieces, Triangulating a Monotone Polygon	1,2,4
Section B		
1	**Orthogonal Range Searching:** 1-Dimensional Range Searching, Kd-Trees, Range Trees, Higher-Dimensional Range Trees, General Sets of Points, Fractional Cascading.	1,4
2	**Voronoi Diagrams:** The Post Office Problem, Definition and Basic Properties, Computing the Voronoi Diagram, Voronoi Diagrams of Line Segments, Farthest-Point Voronoi Diagrams	1,2,4
3	**Delaunay Triangulations:** Triangulations of Planar Point Sets, Definition of Delaunay Triangulation, Computing the Delaunay Triangulation, Development and Analysis of algorithm for Delaunay Triangulation.	1,2
4	**Literature Review:** Recent articles in the field of Computational Geometry published and presented in Journals and Conferences.	3,4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Analyze and design algorithms for complex geometric problems.	1, 2, 5, 6
	CLO2	Map complex engineering problems to computational geometric problems.	1, 2, 5, 6
	CLO3	Understand and verify algorithms published in journals	3, 4, 5, 7
	CLO4	Present own geometric algorithms orally and in writing.	3, 4, 5, 6, 7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Interactive lecturing, Discussions	Class Test Final Examination
2	Discussions Problem solving	Assignment Final Examination
3	Discussions, Cooperative learning	Viva Report Evaluation
4	Cooperative learning, Problem solving, Writing	Presentation Report Evaluation

Learning Materials

Recommended Readings	**Text Book:** M. Berg, O. Cheong, M. Kreveld, M.Overmars, "Computational Geometry Algorithms and Applications", Third Edition, Springer
Supplementary Readings	**Computational Geometry Algorithms Library** https://www.cgal.org/

Course Code: 0714 02 CSE 5205	**Year: First**	**Term: Second**
Course Title: Control Theory		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course enables students to understand and use systems theory and control engineering. It also includes the concept of system stability in time and frequency domains to improve steady state behaviors for excelling system response transient. Course participants will gain the ability to formulate and identify fundamental limitations in control, filtering and estimation.	

	Course Contents	CLOs
	Section A	
1	**Introduction to Control Systems:** Introduction Examples of Control Systems, Closed-Loop Control Versus Open-Loop Control, Design and Compensation of Control Systems	1,2
2	**Mathematical Modeling of Control Systems:** Introduction, Transfer Function and Impulse-Response Function, Automatic Control Systems, Mathematical Modeling of Mechanical Systems, Mathematical Modeling of Electrical Systems, Signal-Flow Graph and Block Diagram Models, Alternative Signal-Flow Graph and	1, 2

	Block Diagram Models (Continuous time and Discrete time domain), Modeling in State Space, State-Space Representation of Scalar Differential Equation Systems, Transformation of Mathematical Models, Linearization of Nonlinear Mathematical Models	
3	**Transient and Steady-State Response Analyses:** Introduction, First-Order Systems, Second-Order Systems, Transient-Response Analysis, Routh's Stability Criterion, Effects of Integral and Derivative Control Actions on System Performance (Continuous time and Discrete time domain), Steady State Errors in Unity-Feedback Control Systems	1, 2, 4
	Section B	
4	**Analysis and Design by the Root-Locus Method:** Introduction, Root-Locus Plots, Plotting Root Loci, Root-Locus Plots of Positive Feedback Systems, Root-Locus Approach to Control-Systems Design, Lead Compensation, Lag Compensation, Lag–Lead Compensation	2,3
5	**Analysis and Design by the Frequency-Response Method**: Introduction, Bode Diagrams, Polar Plots, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion, Stability Analysis (Continuous time and Discrete time domain), Relative Stability Analysis	2,4
6	**Control Systems Analysis in State Space:** Introduction, State-Space Representations of Transfer-Function Systems, Transformation of System Models, Solving the Time-Invariant State Equation, Some Useful Results in Vector-Matrix Analysis, Controllability, and Observability.	2,5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand the basic linear feedback principles and find out the transfer function using various methods.	2, 4, 5
	CLO2	Design system with controller to improve system transient and steady state response	1, 2, 5, 6, 8
	CLO3	Identify the root locus and determine the location of the closed-loop poles	1, 2, 5, 6, 8
	CLO4	Analyze the system using frequency response methods and find stability margins.	1, 2, 5, 6, 8
	CLO5	Present and analyze linear control system using the state space technique	1, 2, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
CLO2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
CLO3	Lecture, problem- based learning and presentation	Assessment and final examination

CLO4	Problem Solving, Brain Storming	Assignments, Term papers, Oral and written examinations
CLO5	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination

Learning Materials

Recommended Textbook	1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India. 2. Benjamin C.Kuo and Farid Golnaraghi "Automatic Control Systems", John Wiley & Sons. 3. Richarc C. Drof and Robert H. Bishop, "Modern Control System", Person Publications. 4. Joseph J Distefano, "Feedback and Control System", Tata macgraw hill publications.

Course Code:0714 02 CSE 5207	**Year: First**	**Term: Second**
Course Title: Engineering Mathematics		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide basic mathematical skill and help to understand, predict, and optimize engineering systems for engineering students.	

	Course Contents	CLOs
	Section A	
1	**Matrix and Gaussian Elimination:** Introduction, Geometry of linear equation, Gaussian Elimination, Matrix Notation and Multiplication	1, 2
2	**Vector Spaces:** Vector spaces and subspaces, Solving Ax=0 and Ax=b, Linear independence, Basics and Dimension, Graphs and Networks, Linear Transformation	1
3	**Orthogonality:** Orthogonal Vectors and subspaces, Cosines and Projection onto Lines, Projection and least squares, Orthogonal bases and gram-schmidt, The Fast Fourier Transform	1, 2
4	**Determinants:** Introduction, Properties of determinants, Formulas of the determinants, Application of determinants	2
	Section B	
5	**Eigenvalues and Eigenvectors:** Introduction, Diagonalization of a matrix, Different Equations and powers, Complex matrices, Similarity transform.	3
6	**Positive Definite Matrices:** Minima, Maxima, and Saddle points, Tests for positive definiteness, Singular value decomposition, Minimum principals, The finite element method.	3, 4
7	**Computation with Matrices:** Introduction, Matrix Norm and condition number, Computation of eigenvalues, Iterative methods for Ax=b	3, 4

8	**Linear Programming and Game Theory:** Linear Inequalities, The simplex method, The dual problem, Network Models, Game Theory.	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Demonstrate knowledge of different techniques and its applications for particular engineering applications.	1, 2, 4
	CLO2	Derive mathematical models of physical systems.	2, 3, 4
	CLO3	Apply mathematical analysis of a variety of experimental and observational studies.	1, 2, 6
	CLO4	Solve different equations using appropriate methods.	1, 2, 5
	CLO5	Present mathematical solutions in a concise and informative manner.	7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
CLO2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
CLO3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination
CLO4	Interactive lecturing, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO5	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	1. Gilbert Strang. Linear Algebra and its Applications. 4th Edition

Course Code:0714 02 CSE 5209	**Year: First**	**Term: Second**
Course Title: Queuing Theory		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	Queuing theory provides models for a number of situations that arise in real life. The course aims at providing necessary mathematical support and confidence to tackle real life problems.	

Course Contents		CLOs
Section A		
1	Stochastic Processes, Discrete Time Markov Chain and Continuous Time Markov Chain	1
2	Exponential distribution, Poisson processes	2
3	Birth-Death Process in Queuing.	2
4	Limiting distributions, semi-Markov process	2
Section B		
5	Queuing Models: M/M/1, M/M/C, M/G/I. M/D/I, G/M/I	2
6	Solution of Network of Queues, Closed Queuing Models and Approximate Models.	2 3
7	Brownian motion, geometric Brownian motion, white noise, Gaussian process, stationary and weakly stationary process	23
8	Application of Queuing Models in Computer Science	3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Illustrate the basic concepts of stochastic process and different Markov process.	1
	CLO2	Use key formulas for approximating important properties (stationary probabilities, average waiting and response time, expected number of customers, etc.) of queuing models such as M/M/c, M/G/1, etc.	2, 6
	CLO3	Design capacity models (routers, switch) in computer networking system using various queuing systems	2, 6
	CLO4	Contrast among different networking/ computing service systems using queuing systems.	6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Group Discussions, Problem solving	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. S. M. Ross. *Introduction to Probability Models*, 9th Edition, 2007. 2. K. L. Chung. *Markov Chains with Stationary Transition Probabilities*, Springer, 2nd Edition, 1957. 3. E. Cinlar. *Introduction to Stochastic Processes*. Dover Publications, Reprint Edition, 2013 4. L. Kleinrock. *Queuing Theory Vol. I & II*. Wiley-Interscience, 1976.

Course Code:0714 02CSE 5211	**Year: First**	**Term: Second**
Course Title: Software Evolution and Maintenance		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to make the learners aware about the recent research and the state-of-the-art tools and techniques to efficiently maintain the evolution of software systems.	

	Course Contents	CLOs
	Section A	
1	**Code Clones:** Different Type of Code Clones, Clone detection techniques, Clone refactoring and tracking, Lambda expressions in Java and Application of these in clone refactoring,	1
2	**Impacts of Code clones:** Impacts of code clones on software evolution and maintenance, existing research and outcomes on clone impacts, relationships of code clones with software bugs.	1
3	**Evolutionary Coupling:** Association Rule Mining, Existing Association Rule Mining Techniques, Application of Association Rule Mining in software engineering tasks such as co-change recommendation and bug-localization.	2, 4
	Section B	
4	**Recommendation System:** Recommending co-change candidates, Autocompletion, Change recommendation and change completion, Recent research on recommendation systems	3

5	**Bug Localization:** Different bug-localization techniques; File level, method level and fragment level bug-localization, Recent papers on bug-localization.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Explain code clones and their impacts in software systems, apply different clone refactoring and tracking techniques for managing code clones, and provide solutions for minimizing software bugs.	2
	CLO2	Explain association rule mining and apply the related techniques for different software engineering tasks.	2, 3
	CLO3	Explain different recommendation systems that are currently being used in software engineering, identify the drawbacks of the existing recommendation systems, investigate, propose and devise mechanisms for improving the existing recommendation systems.	7, 8
	CLO3	Use different bug-localization techniques to locate bugs in the code-base and explain the working procedure of these techniques.	2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, discussion, question and answer session	Class tests, quiz,, final examination
3	Lecture, discussion, question and answer session	Class tests, programming assignments, final examination
4	Lecture, discussion, question and answer session	Class tests, programming assignments, final examination

Learning Materials

Recommended Textbook	1. Software Evolution and Maintenance: A Practitioner's Approach by Kshirasagar Naik and PriyadarshiTripathy 2. Manishankar Mondal, Chanchal K. Roy, Kevin A. Schneider. "Automatic Ranking of Clones for Refactoring through Mining Association Rules", in Proceedings of CSMR-WCRE 2014, Antwerp, Belgium, February 2014, 10 pp. IEEE 3. C.K. Roy and J.R. Cordy, "A Survey on Software Clone Detection Research", Technical Report 2007-541, School of Computing, Queen's University, September 2007, 115 pp. 4. M. Masudur Rahman and C.K. Roy, "Improving IR-Based Bug Localization with Context-Aware Query Reformulation", In

	Proceeding of The 26th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE 2018), pp. 621–632, Florida, USA, November, 2018.

Course Code:0714 02 CSE 5213	**Year: First**	**Term: Second**
Course Title: Wireless Ad-Hoc and Sensor Networks		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	The goal of this course is to learn basic concepts of Ad-Hoc and Wireless sensor networks, to be familiar with architecture and protocols used in Ad-Hoc and Wireless sensor networks and to provide knowledge of deployment and security issued of Ad-Hoc and Wireless sensor networks.	

Course Contents		**CLOs**
	Section A	
1	MAC & TCP IN AD HOC NETWORKS: Fundamentals of WLANs, IEEE 802.11 Architecture, Self-configuration and Auto configuration, Issues in Ad-Hoc Wireless Networks, MAC Protocols for Ad-Hoc Wireless Networks, Contention Based Protocols-TCP over Ad-Hoc networks, TCP protocol overview-TCP and MANETs, solutions for TCP over Ad-Hoc Networks.	1
2	ROUTING IN AD HOC NETWORKS: Routing in Ad-Hoc Networks, Introduction, Topology based versus Position based Approaches, Proactive, Reactive, Hybrid Routing Approach, Principles and issues ,Location services, DREAM ,Quorums based location service, Grid–Forwarding strategies, Greedy packet forwarding ,Restricted directional flooding, Hierarchical Routing, Issues and Challenges in providing QoS.	2
	Section B	
3	MAC, ROUTING & QOS IN WIRELESS SENSOR NETWORKS: Introduction, Architecture, Single node architecture, Sensor network design considerations ,Energy Efficient Design principles for WSNs, Protocols for WSN, Physical Layer : Transceiver Design considerations, MAC Layer Protocols ,IEEE802.15.4 Zigbee, Link Layer and Error Control issues-Routing Protocols, Mobile Nodes and Mobile Robots, Data Centric & Contention	3
4	SENSOR MANAGEMENT: Sensor Management, Topology Control Protocols and Sensing Mode Selection Protocols, Time synchronization, Localization and positioning, Operating systems and Sensor Network programming, Sensor Network Simulators.	4
5	-SECURITY IN AD HOC AND SENSOR NETWORKS: Security in Ad-Hoc and Sensor networks, Key Distribution and Management, Software based Anti-tamper techniques, water marking techniques, Defence against routing attacks, Secure Adhoc routing protocols, Broadcast authentication WSN protocols, TESLA, Biba, Sensor Network Security Protocols, SPINS.	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	understand the basics of Ad-hoc and Sensor Networks	1, 2
	CLO2	learn various fundamental and emerging protocols of all layers.	2, 5, 6
	CLO3	study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks	1, 2, 5, 6
	CLO4	understand the nature and applications of Ad-hoc and sensor networks	2, 5, 6, 8
	CLO5	understand various security practices and protocols of Ad-hoc and Sensor Networks	1, 2, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Ad Hoc Wireless Networks: Architectures and Protocols, C. Siva Ram Murthy, B.C. Manoj, Prentice Hall, 1st Edition, 2004. 2. Charles .E. Perkins, "Ad Hoc Networking", Pearson Education, 2008 3. C.K.Toh, "Ad Hoc Mobile Wireless Networks-Protocols and Systems", Pearson Education, 2009. 4. .Carlos De Morais Cordeiro, Dharma Prakash Agrawal "Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition), World Scientific Publishing, 2011.

Course Code:0714 02 CSE 5215	**Year: First**	**Term: Second**
Course Title: Future Internet		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	The goal of this course is to discuss the principles and technologies arising from the need to spread the research areas of Future Internet.	

Course Contents		CLOs
Section A		
1	Introduction to Future Internet, Future Internet Architecture	1
2	Access network for FI	2
3	Open source for FI, FI service/applications	2
4	Routing and Mobility in FI	3
Section B		
5	Manageability in FI, Naming and Addressing in FI	4
6	SDN and ICN in Future Internet	4
7	IoT and 5G in FI	5
8	Security Issues in FI	5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	understand the basics of future internet and its architecture	1, 2
	CLO2	learn various access network, services/applications in FI	2, 5, 6
	CLO3	Learn about the routing and mobility techniques in FI	1, 2, 5, 6
	CLO4	understand the manageability issues in FI	2, 5, 6, 8
	CLO5	understand role of IoT and 5G and also the security issues in FI	1, 2, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. The Future Internet, Future Internet Assembly 2011: Achievements and Technological Promises (Springer)

Course code: 0714 02 CSE 5217 **Course Title:** Advanced Information security	**Year: First**	**Term: Second**
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): NILL		
Rationale	This course introduces the concepts and issues related to securing advanced information systems and the development of policies and mechanisms to implement advanced security services.	

Course Contents		CLOs
Section A		
1	**Introduction:** Review of basic information security mechanisms, wiretapping, impersonation, hacking, cracking, phishing, ID theft, authentication and authorization. .	1
2	Issues of Network security, treats to network security:	1, 2
3	firewalls, Virtual private networks, intrusion detection system;	2, 3
4	Secure network devices; security policies ; internet vulnerabilities;	2, 3
Section B		
5	Web security, IPSec, SSL,TSl	2, 3, 4
6	E-mail security, e-commerce security.	2, 3, 4
7	User Authentication for a complex system.	2, 3, 4
8	Security Issues of a complex system like smart campus, smart city	1,2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand how data can be secured at the station as well as in transition. Explain and design advanced security mechanism and services	1
	CLO2	Protect data using appropriate security mechanisms.	1, 2, 3
	CLO3	Explain advanced security mechanism and services	2, 3, 4
	CLO4	Design and analyze advanced information system and design new or modified security mechanisms and services for the complex system.	2,, 3, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming, Project Design	Assignments, Term papers, Oral and Written examinations

Learning Materials

Recommended Readings	1. Cryptography and Network Security, William Stallings, Prentice Hall, 6th Edition, 2013. 2. Java 2 Network Security, Marco Pistola, Duane F. Reller, Deepak Gupta, MilindNagnur, 2nd Edition, 1999. 3. Network Security Architectures, Sean Convery, Cisco Press, 1st Edition, 2004.

Course Code:0714 02 CSE 5219	**Year: First**	**Term: Second**
Course Title: Game Theory in wireless and Communication Network		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	The goal of this course is to address the challenges from the distributed management of wireless and communication networks, through the lens of game theory. Game theory provides a formal framework with a set of mathematical tools to study the complex interactions among interdependent rational players.	

	Course Contents	CLOs
	Section A	
1	Introduction and overview of Game Theory and application area in wireless and communication network	1
2	Basic Non-cooperative Games: Games in normal (strategic) form, Games in extensive form, Continuous-kernel games and application areas	2
3	Advanced Non-Cooperative Games: Repeated games, Correlated equilibrium	2
	Section B	
4	Bargaining Cooperative Games: Nash Bargaining and related solutions, Dynamic Bargaining	3
5	Coalitional Games: Canonical games and applications, Coalition formation games and applications, Graph games and applications	3
6	Learning in Games: The algorithmic side of game theory, Importance in applications	4
7	Auctions, Matching and Contracts: Economic side of game theory and its applications	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	understand the basics of game theory and its application areas	1, 2

	CLO2	learn the concepts of non-cooperative game	2, 5, 6
	CLO3	Formalize cooperative game	1, 2, 5, 6, 8
	CLO4	Learn the solution concept of the game	2, 5, 6, 8
	CLO5	understand the economic side of the game through auction, matching and contracts	2, 5, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions, Problem Solving	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Z.Han, D.Niyato, W.Saad, T.Başar, and A.Hjørungnes, Game Theory in Wireless and Communication Networks: Theory, Models, and Applications, Cambridge University Press, September 2011. 2. Michael Maschler, EilonSolan, Shmuel Zamir, Game Theory, Cambridge University Press (2013)

Course Code:0714 02 CSE 5221	**Year: First**	**Term: Second**
Course Title: Blockchain Technology and Applications		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to introduce the fundamental concepts related to blockchain technology and its relevant applications. After completing this course, students will be able to explore and explain blockchain related applications.	

	Course Contents	CLOs
	Section A	
1	Basics of cryptography, hashing and peer-to-peer communication.	1, 2
2	Essential concepts of blockchain, blockchain categories, decentralization,	1
3	Distributed database, distributed ledger technology, consensus protocols.	3
	Section B	

4	Blockchain 1.0: Cryptocurrency details	4, 5
5	Blockchain 2.0: Smart Contracts. Dapps, DAOs, DACs, and DASs details.	4, 5
6	Blockchain 3.0: Digital Identity verification, Digital Art, Government Services, Health, etc. applications.	4, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Define blockchain fundamentals, blockchain types, and history.	1, 2, 3, 4, 8
	CLO2	Apply cryptography and peer-to-peer communication to build up blockchain systems.	1, 2, 4, 8
	CLO3	Describe distributed ledger technology and consensus protocols.	1, 2, 4, 8
	CLO4	Design smart contracts for various types of applications.	1, 2, 4, 8
	CLO5	Evaluate different types of blockchain applications for multitude of application fields.	1, 2, 4, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO5	Lecture, presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	1. The Science of the Blockchain – Roger Wattenhofer, First edition, 2016, Inverted Forest Publishing. 2. Blockchain For Dummies – Tiana Laurence, John Wiley & Sons, 2017. 3. Blockchain blue print of a New Economy – Melanie Swan, O'Reilly, 2015

Course Code:0714 02 CSE 5223	**Year: First**	**Term: Second**
Course Title: Temporal Logic and Model Checking		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		

Rationale	This course is designed to introduce the use of temporal logic for specifying properties of hardware and software and to use model checking as a method for checking that properties hold or finding counter-examples.

Course Contents		**CLOs**
Section A		
1	State transition systems. Representation of state spaces. Reachable states.	1, 2
2	Checking reachability properties Fixed-point calculations. Symbolic methods using binary decision diagrams. Finding counter-examples.	1, 2
3	Illustration with Examples. Various uses of reachability calculations.	2, 3
4	Temporal properties. Linear and branching time. Intervals. Path quantifiers.	1, 2,3
Section B		**CLOs**
5	Temporal logic. Brief history (Prior to Pnueli). CTL and LTL. Standarised logics: PSL.	1, 3
6	Model checking. Simple algorithms for verifying that temporal properties hold. Reachability analysis as a special case.	2, 3
7	Applications. Software and hardware examples.	1, 2, 3
8	Advanced methods. Brief introduction to recent development, e.g. Counter-example guided abstraction refinement (CEGAR).	1, 2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	write properties in a variety of temporal logic	1, 5, 6
	CLO2	be familiar with the core ideas of model checking	2, 5, 6
	CLO3	understand what commercial model checking tools can be used for	5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO2	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination
CLO3	Interactive lectures, Discussions, Problem solving	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Textbook	

Course Code: 0714 02 CSE 5225	**Year: First**	**Term: Second**
Course Title: Advanced Pattern Recognition		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is designed to provide the students with knowledge needed to understand the techniques for designing automated systems using pattern recognition algorithms. This course covers the methodologies, technologies, and algorithms of pattern recognition from a variety of perspectives. Topics includes Formal languages for pattern description, Higher dimensional pattern grammars, Syntax analysis as a recognition procedure, Error-correcting tree automata, Cluster analysis for syntactic patterns, Grammatical inference for syntactic pattern recognition, Application shape analysis of wave forms and contours, Syntactic approach to texture analysis etc.	

Course Contents		**CLOs**
Section A		
1	Introduction to formal languages,	1,2
2	String languages for pattern description	1, 2, 3
3	Higher dimensional pattern grammars	1,2, 4
4	Syntax analysis as a recognition procedure	2, 3
5	Stochastic languages, Error-correcting parsing for string languages,	2, 4

Section B		**CLOs**
6	Error-correcting tree automata	2, 4
7	Cluster analysis for syntactic patterns	2, 3, 4
8	Grammatical inference for syntactic pattern recognition	2, 3, 4
9	Application shape analysis of wave forms and contours	1,2,
10	Syntactic approach to texture analysis.	1, 2,4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to		**Mapping with PLOs**
	CLO1	Understand advanced concepts in pattern recognition	1, 2
	CLO2	Infer pattern recognition theories	1, 2, 4
	CLO3	Apply pattern recognition techniques in practical problems.	1, 2, 4, 5, 6
	CLO4	Gain knowledge about state-of-the-art algorithms used in pattern recognition research.	1, 2, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming	Assignments, Term papers, Oral and written examinations

Learning Materials

Recommended Readings	1. Pattern recognition: Statistical, Structural, and Neural Approaches, Robert J. Schalkoff, J. Wiley, 1992. 2. Pattern Recognition and Image Analysis, Earl Gose, Richard Johnsonbaugh, Steve Jost, Prentice Hall, Har/Dsk Edition, 1996. 3. Advanced Pattern Recognition Technologies with Applications to Biometrics, David Zhang, Fengxi Song, Yong Xu, Zhizhen Liang, Medical Information Science Reference, 1st Edition, 2008.
Supplementary Readings	

Course Code: 0714 02 CSE 5227	**Year: First**	**Term: Second**
Course Title: Knowledge Representation and Reasoning		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is designed to provide the students with knowledge needed to understand knowledge representation and automated reasoning techniques and systems. Students acquire knowledge about knowledge representation and uses in computers, logic-based languages for KR, applications of KR and automated reasoning techniques and systems.	

Course Contents		CLOs
Section A		
1	Introduction to knowledge-based technologies and knowledge representation	1,2
2	Propositional Logic as a simple knowledge representation language	1,2,5
3	Representing Knowledge in First Order Predicate Logic	1,5
4	Limitations of Propositional and First Order Predicate Logic	1,5

Section B		CLOs
5	Description Logics as Knowledge Representation Languages	2,4
6	Reasoning in Description Logics	3,4

7	Horn Fragments of First Order Logic. Rule-based Knowledge Representation and Reasoning	1,3,4
8	Ontologies and Ontology Languages	2,4
9	Other Decidable Fragments of First Order Logic for Knowledge Representation	1,5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to		**Mapping with PLOs**
	CLO1	Understand the fundamental principles of logic-based Knowledge Representation	1, 2, 5
	CLO2	Understand and able to model simple application domains in a logic-based language	1, 2, 5, 6
	CLO3	Understand the notion of a reasoning service	1, 2, 5, 6
	CLO4	Able to apply the reasoning algorithms underlying current systems;	1, , 2, 4, 5, 6, 8
	CLO5	Understand the fundamental trade-off between representation power and computational properties of a logic-based representation language	4, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming	Assignments, Term papers, Oral and written examinations
5	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination

Learning Materials

Recommended Readings	1. Knowledge Representation and Reasoning, Ronald J. Brachman, Hector J. Levesque, Morgan Kaufmann, 1st Edition, 2004. 2. Foundations of Knowledge Representation and Reasoning, edited by Gerhard Lakemeyer, Bernhard Nebel, Springer, 1994. 3. Knowledge Representation, Reasoning and Declarative Problem Solving, ChittaBaral, Cambridge University Press, 1st Edition, 2010.
Supplementary	2. Handbook of Knowledge Representation. Frank van Harmelen,

Readings	Vladimir Lifschitz and Bruce Porter (Eds). Foundations of Artificial Intelligence, 2008.

Course Code:0714 02 CSE 5229	**Year: First**	**Term: Second**
Course Title: Data Mining and Warehousing		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to introduce data warehousing technology to the students so that students can plan, create, maintain, promote, and support any large-scale data warehouse.	

	Course Contents	**CLOs**
	Section A	
1	Introduction to data warehousing and its need.	1
2	Building blocks of data warehousing, defining features, data marts and warehouse components.	2
3	Data warehouse planning, project management, project team, business requirements.	3
4	Data design, storage specifications, information delivery strategy.	4
	Section B	
5	Data warehousing architecture, architectural framework, data acquisition, and storage.	5
6	Data modeling, extraction, transformation, loading, and data quality.	5
7	Dimensional modeling, data design, STAR schema, Snowflake schema, ETL	5, 6
8	OLAP in data warehouse, data cubes, drill-down, roll-up, slide-and-dice, OLAP platforms, tools and products.	6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Describe data warehouse needs.	1, 2
	CLO2	Describe building blocks of data warehousing, data marts and warehouse components.	1, 2
	CLO3	Describe data warehouse planning, project management, and business requirements.	1, 2, 4, 7, 8
	CLO4	Design data warehouse, storage and delivery strategy.	1, 2, 4, 5, 6, 8
	CLO5	Design data warehouse architecture, dimension modelling, ETL process, schemas.	1, 2, 3, 4, 5, 6, 8
	CLO6	Apply OLAP and data cube operations.	1, 2, 3, 4, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO5	Lecture, presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.
CLO6	Lecture, presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials

Recommended Textbook	4. Data Warehousing Fundamentals: A Comprehensive Guide for IT Professionals, Paulraj Ponniah, John Wiley & Sons, 2001 5. Data Warehousing Architecture and Implementation, Mark W. Humphries, Michael W. Hawkins, Michelle C. Dy, Prentice Hall, 1999 6. Data Warehousing for Dummies, Thomas C. Hammergren, Alan R. Simon, Wiley Publishing, 2009.

Course Code: 0714 02 CSE 5231	**Year: First**	**Term: Second**
Course Title: Network Optimization		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is about the networking technologies we use every day as well as the fundamental ideas in the field. Each topic is selected not just for its relevance to our daily lives, but also for the core concepts and key methodologies in the field of networking that are illustrated by its answer. This course will help to explore recent scientific efforts to explain social, economic and technological structures and the way these structures interact on many different scales, from the behavior of individuals or small groups to that of complex networks such as the Internet and the global economy.	

Course Contents		CLOs
Section A		
1	**Introduction and Overview** Structural Properties of Networks, Contagion in Networks, The Structural Virality of Online Diffusion, Structural Diversity in Social Contagion, Scientific simulations and models	1,2,3, 4
2	**Machine Learning and Social Networks** Network Analysis of Squash Matches, Romantic Partnerships and the Dispersion of Social Ties: A Network Analysis of Relationship Status on Facebook, Private Traits and Attributes are Predictable from Digital Records of Human Behavior, Graph Theory, Content Distribution Web, Aggregation and Influence, Ad spaces and Web Page Ranking, Automated Recommendation, Content Rating, Influencing People on Social Media	1,2,3, 4
3	**Navigation in Networks** An Experimental Study of the Small World Problem, An Experimental Study of Search in Global Social Networks, Navigation in a Small World, Identity and Search in Social Networks, The Scaling Laws of Human Travel, Distributed Coordination, Feedback Control, Internet Traffic, Congestion	1,2,3, 4
4	**How Do Real Networks Look?,** Four Degrees of Separation, Heavy Tails, Small Diameter, Clustering of Connectivity, Optimization Theory, Wireless Internet	1,2,3, 4
Section B		**CLOs**
5	**Models of Network Formation** The Erdos-Renyi Model, Clustering Models, Preferential Attachment	1,2,3, 4
6	**Incentives and Collective Behavior** Micromotives and Macrobehavior, Towards Rational Dynamics in Networks	1,2,3, 4
7	**Networked Game Theory** Introduction to (Networked) Game Theory, Basics of Game Theory, Networked Games: Coloring, Consensus and Voting; Network Formation Games, Strategic Equilibrium	1,3,4
8	**Algorithmic Privacy** Algorithmic Privacy and Fairness, The Ethical Algorithm, Algorithms, People and Game Theory; Online Social Internet Economics, Business models of Skype and Bit Torrent	1,5

	Upon completion of this course the students will be able to		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Explain the networking technologies and fundamental ideas people use every day including the principles and mathematical modelling of different network problems.	2, 4, 5
	CLO2	Identify a network behavior easily and solve network problems using appropriate models.	1, 4, 5, 6, 8
	CLO3	Compare different network optimization approaches and identify the best.	1, 2, 4, 5, 8
	CLO4	Explain the industry standard practices in network and social system engineering and implement various obtained algorithmic solutions with ease.	2, 4, 5, 6, 7, 8
	CLO5	Discover and discuss network-based	1, 4, 7, 8

		business models and apply ethical responsibilities in solving different network problems.	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and group presentation	Assignment, Assessment and final examination
4	Problem Solving, Algorithm Implementation, Brain Storming	Assignments, Term papers, Oral and written examinations
5	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination

Learning Materials

Recommended Readings	Textbook: 1. Networked Life: 20 Questions and Answers by MUNG CHIANG, Princeton University 2. Six Degrees: The Science of a Connected Age, by Duncan J. Watts. W.W. Norton, 2003.
Supplementary Readings	1. Micromotives and Macrobehavior, by Thomas C. Schelling. W.W. Norton, 1978. 2. Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy, by Cathy O'Neil. Crown, 2016. 3. The Ethical Algorithm, by Michael Kearns and Aaron Roth, Oxford University Press, 2019.

Course Code:0714 02 CSE 5233	**Year: First**	**Term: Second**
Course Title: Human-Computer Interaction		
Course Status: Optional/Elective		
Credit:		
Prerequisite(s): None		
Rationale	Psychopathology of everyday things: visibility, affordances, natural mapping; psychology of everyday actions: seven stages of action gulf of execution and evaluation; knowledge in the head and in the world; constraints; human errors; design challenges; user-centered design; Cognetics and locus of attention; meaning, modes, monotony, myths; quantification; unification; navigation.	

Course Contents		CLOs
Section A		
1	The scope and challenges of HCI and Interaction Design.	1,2
2	Visual representation. Segmentation and variables of the display plane. Modes of correspondence	
3	Text and gesture interaction. Evolution of interaction hardware. Measurement and assessment of novel methods.	
4	Inference-based approaches. Bayesian strategies for data entry, and programming by example.	
5	Augmented reality and tangible user interfaces. Machine vision, fiducial markers, paper interfaces, mixed reality.	3
Section B		
6	Usability of programming languages. End-user programming, programming for children, cognitive dimensions of notations.	
7	User-centred design research. Contextual observation, prototyping, think-aloud protocols, qualitative data in the design cycle.	1, 2, 3
8	Usability evaluation methods. Formative and summative methods. Empirical measures. Evaluation of part II projects.	

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Provide a brief idea of HCI and interation design.	1,2,3
	CLO2	Learn the Evolution of interaction hardware and its application in different sectors.	3,5,6
	CLO3	Understanding of Augmented reality, tangible user interfaces and Usability analysis.	1,3,5,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing, Discussions, Problem solving	Quiz Class Test
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Assignment Class Test
CLO3	Presentations	Group Study Final Project Presentations

Learning Materials

Recommended Readings	**Text Book:** Human-Computer Interaction, Alan Dix, Janet Finlay Gregory, D. Abovod, Russell Beale, Prentice Hall, 3rd Edition, 2003.

Supplementary Readings	**Reference Book:** 1. Human-Computer Interaction in the New Millennium, John M. Carroll, Addison-Wesley Professional, 1st Edition, 2001. 2. Interaction Design: Beyond Human - Computer Interaction, Yvonne Rogers, Helen Sharp, Jenny Preece, Wiley Publishers, 3rd Edition, 2011.

Course Code:0714 02 CSE 5235	**Year: First**	**Term: Second**
Course Title: Computational Imaging		
Course Status: Optional/Elective		
Credit:3.00		
Prerequisite(s): None		
Rationale	This course will cover basic principles of computational imaging, including image denoising, regularization techniques, linear inverse problems and optimization-based solvers, and data acquisition models associated with tomography and interferometry. Specific topics may include patch-based denoising, sparse coding, total variation, dictionary learning, computational photography, compressive imaging, and deep learning for image reconstruction.	

Course Contents		**CLOs**
Section A		
1	**Introduction:** Introduction to Computational Imaging and the image processing techniques, Survey image processing techniques.	1
2	**Denoising:** Kernel methods - smoothing, bilateral filter, non-local means, BM3D, wavelets and soft thresholding.	1, 2
3	**Deblurring:** Fourier transforms of images, Least squares vs. Tikhinov regularization, Gradient descent.	1, 2, 3
Section B		
1	**Computed Tomography:** Fourier slice theorem, Filtered backprojection.	3
2	**Regularization and optimization:** Wavelets and L1 regularization, Total variation, Proximal-gradient algorithms, ADMM.	2, 3
3	**Learned Reconstruction:** Patch-based regularization, K-SVD, Dictionary Learning.	2, 3
4	**Deep Learning for Image Reconstruction:** Artificial Neural Networks, Convolutional Neural Networks.	4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Demonstrate the knowledge of different imaging techniques and their applications for particular	1, 5, 6

		problems.	
	CLO2	Understand computational imaging methods and applications focusing on solving inverse problems in imaging, such as denoising, deblurring, single-pixel imaging, and others.	2, 5, 6
	CLO3	Apply several mathematical analyses in various experimental studies of computational imaging.	2, 6, 8
	CLO4	Explore the functional components of neural network classifiers that are used for image reconstruction.	2, 4, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Interactive lectures, Discussions	Class Tests, Assignments, Final Examination
2	Interactive lecturing, Discussions	Class Tests, Assignments, Final Examination
3	Interactive lecturing, Discussions, Class works	Class Tests, Assignments, Final Examination
4	Interactive lecturing, Discussions, Problem solving	Class Tests, Assignments, Final Examination

Learning Materials

Recommended Readings	TextBook(s): 1. Computational Imaging, A. Bhandari, A. Kadambi and R. Raskar, The MIT Press, 2022. 2. Deep Learning for Vision Systems, Mohamed Elgendy, Manning Publications, 1st Edition, 2020.
Supplementary Readings	1. Chambolle, A., Caselles, V., Cremers, D., Novaga, M., & Pock, T. (2010). An introduction to total variation for image analysis. Theoretical foundations and numerical methods for sparse recovery, 9 (263-340), 227. 2. link.springer.com/chapter/10.1007/978-981-16-7621-5_3 3. stanford.edu/class/ee367/reading/ee367_notes_noise.pdf

Course Code:0714 02 CSE 5237	**Year: First**	**Term: Second**
Course Title: Parallel Algorithms		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide advanced knowledge on parallel processing, related algorithms, and techniques so that the learners can efficiently use those algorithms and techniques in their research and practice.	

Course Contents		CLOs
Section A		
1	**Introduction:** Parallel processing, Parallel models, Performance of Parallel Algorithms, The work-time presentation framework.	1
2	**Basic techniques:** Pointer jumping, Balanced trees, Divide and Conquer, Pipelining, Partitioning and symmetry breaking, List ranking, Euler-Tour technique, Tree contraction.	2
Section B		**CLOs**
3	Parallel searching, merging, sorting and selection, Connected components, Minimum spanning trees, Biconnected Components, Directed graphs.	3
4	Plane sweeping, Visibility problems, Simulation between PRAM models, Lower bounds for EREW, CREW and CRCW PRAMs.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Explain the general concept of parallel processing, different parallel processing models and algorithms.	1
	CLO2	Apply the basic parallel processing techniques for designing parallel algorithms.	2
	CLO3	Apply parallel searching and merging algorithms, techniques, and tools for merging outputs from multiple parallel processes.	4
	CLO4	Explain and efficiently use the plane sweeping algorithm and its variations, and different simulation techniques between PRAM models.	2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
CLO2	Lecture, discussion, question and answer session	Class tests, quiz,, final examination
CLO3	Lecture, discussion, question and answer session	Class tests, quiz,, final examination
CLO4	Lecture, discussion, question and answer session	Class tests, quiz,, final examination

Learning Materials

Recommended Textbook	1. Introduction to Parallel Algorithms, C. Xavier, S. S. Iyengar, Wiley-Interscience, 1st Edition, 1998. 2. Parallel algorithms, Henri Casanova, Arnaud Legrand, Yves Robert, Chapman and Hall/CRC, 2008. 3. Efficient Parallel Algorithms, Alan Gibbons, Wojciech Rytter, Cambridge University Press, 1989. 4. Parallel Computer Architecture: A Hardware/Software Approach, David E. Culler, Jaswinder Pal Singh, and Anoop Gupta, Morgan Kaufmann Publishers, 1998.

Course Code:0714 02 CSE 5239	**Year: First**	**Term: Second**
Course Title: Big Data Analytics		
Course Status: Optional/Elective		
Credit:		
Prerequisite(s): None		
Rationale	The explosion of social media and the computerization of every aspect of social and economic activity resulted in creation of large volumes of mostly unstructured data: web logs, videos, speech recordings, photographs, e-mails, Tweets, and similar. In a parallel development, computers keep getting ever more powerful and storage ever cheaper. Today, we have the ability to reliably and cheaply store huge volumes of data, efficiently analyze them, and extract business and socially relevant information. The key objective of this course is to familiarize the students with most important information technologies used in manipulating, storing, and analyzing big data. We will examine the basic tools for statistical analysis, R and Python, and several machine learning algorithms.	

	Course Contents	**CLOs**
	Section A	
1	Basic Statistics and R.	1
2	Relationships and Representations, Graph Databases.	
3	Introduction to Spark 2.0. Language processing with Spark 2.0. Introduce one of NoSQL databases for fast storage and retrieval of big volumes of textual data.	
4	Analysis of Streaming Data with Spark 2.0. Introduce a special messaging system (Kafka) which is a necessary buffer between actual data sources and Spark processing engine.	
5	Applications of Spark ML Library.	2
	Section B	
6	Basic Neural Network and Tensor Flow. Learn how to use Tensor Flow both on GPU and CPU machines.	
7	Assessing Quality of Big Data Analysis. Learn also learn how to access precision of other large scale calculations.	1, 3
8	Analysis of Images, OCR Applications. Learn how to use some standard API-s to perform such analysis at big data speed.	
9	Page Rank like Search systems. Searching through large volumes of textual data at very high speed is what made Google.com possible.	
10	Analysis of Streaming Data with Tensor Flow, VoltDB, Data Flow Engines and other memory databases.	

Course Learning	Upon completion of this course the students will be able to:	**Mapping with PLOs**

	CLO1	Provide a brief idea of Statistics, R and Spark 2.0	1,2
	CLO2	Analysis and develop using Spark ML Library and Tensor Flow.	4,5,6
	CLO3	Assessing Quality of Big Data Analysis, Page ranking mechanism analysis	1,3,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing, Discussions, Problem solving	Quiz Class Test
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Assignment Class Test
CLO3	Presentations	Group Study Final Project Presentations

Learning Materials

Recommended Readings	**Text Book:** Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses Authors: Michael Minelli, Michele Chambers, Ambiga Dhiraj Publisher: John Wiley & Sons, 2013 ISBN: 111814760X
Supplementary Readings	**Reference Book:** 1. Data Analytics and Big Data Authors: Soraya Sedkaoui Publisher: John Wiley & Sons, 2018 ISBN: 1786303264 2. Big Data in Practice: How 45 Successful Companies Used Big Data Analytics to Deliver Extraordinary Results Authors: Bernard Marr Publisher: John Wiley & Sons, 2016 ISBN: 1119231388

Course Code: 0714 02 CSE 5241	**Year: First**	**Term: Second**
Course Title: Distributed Databases		
Course Status: Optional/Elective		
Credit: 3.0		
Prerequisite(s): None		
Rationale	**Rationale:** This course is designed to provide the students with knowledge needed to understand distributed database management system. Students acquire knowledge about distributed databases and components of a distributed database management system including distributed database design, data fragmentation, replication, and allocation; database security, transaction management with concurrency control and recovery, query processing and optimization.	

Course Contents		CLOs
Section A		
1	Principles in the design and implementation of distributed databases	1
2	Distributed computing concepts and distributed transaction processing systems	1, 2, 3
3	Distributed transaction processing systems	2, 3
4	Distributed and multi-database system architectures and models	2, 3, 5

Section B		CLOs
5	Atomicity, synchronization and distributed concurrency control algorithms	2, 3
6	Data replication	4,5
7	Recovery techniques	4,5
8	Reliability in distributed databases	1, 3

	Upon completion of this course the students will be able to		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand distributed database systems architecture and design	1, 2, 5, 6
	CLO2	Able to apply methods and techniques for distributed quey processing and optimization	1, 2, 5, 6, 8
	CLO3	Understand the broad concepts of distributed transaction process	1, 2
	CLO4	Understand the basic concepts of Data warehousing and OLAP technology	1, 2, 5, 6, 8
	CLO5	Able to apply methods and techniques for association analysis, data classification and clustering	2, 4, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
1	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination
2	Lecture, Problem-based Learning and answer, and question session	Quiz, Class tests, and written examination
3	Lecture, problem- based learning and presentation	Assessment and final examination
4	Problem Solving, Brain Storming	Assignments, Term papers, Oral and written examinations
5	Lecture, discussion, question and answer session	Quiz, Class tests, and written examination

Learning Materials

Recommended Readings	1. Principles of Distributed Database Systems, M. Tamer Ozsu, Patrick Valduriez, Springer, 3rd Edition, 2011. 2. Distributed Database Management Systems: A Practical Approach, Saeed K. Rahimi, Frank S. Haug, John Wiley & Sons, 2010. 3. Distributed Databases, Stefano Ceri, Giuseppe Pelagatti, Tata McGraw-Hill Education, 1984.
Supplementary Readings	1. Digital Communications, Proakis, J. G., MA: McGraw-Hill, 4th Edition, 2001.

Course Code:0714 02 CSE 5243	**Year: First**	**Term: Second**
Course Title: Advanced Microprocessors and Embedded System		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide enhanced knowledge on the architecture of microprocessors and microcontrollers. Students will be able to understand the sequential upgradations of the microprocessors and show in-depth knowledge on modern microcontrollers.	

Course Contents		**CLOs**
Section A		
1	Review of different microprocessors: 80486, 68040, V70, Gmicro processors	1, 2
2	Comparing the architectures: RISC and CISC; Instruction set of machines: SPARC, INTEL, and MIPS	1, 2
3	Study of microprocessors: Pentium II, Alpha 21064, MIS 6400, PA-RISC; Math coprocessors and microprocessors	1, 2, 3
Section B		**CLOs**
1	Multi-user and real-time multitasking support; multiprocessing support: bus interfacing, arbitration and communication mechanism, real-time signal processing.	2, 3, 4
2	Modern microcontrollers and their usage in complex embedded systems.	2, 4, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	To compare between generations of microprocessors and microprocessor-based systems.	2
	CLO2	To demonstrate knowledge on the inner workings of a fully functional microprocessor and microprocessor-based systems.	2
	CLO3	To identify the compromises	1, 2

		required for balancing between performance and limitations.	
	CLO4	To construct feasible subset-architectures.	1
	CLO5	To model embedded systems.	1, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. The Intel Microprocessors 8086/8088, 80/86 80188 80286, 80386, 80486, Pentium and Pentium Processor, Barry B, Brey, Prentice Hall, 8th Edition, 2008. 2. Microprocessor Architecture Program and Applications with the 8085, Ramesh S. Ganokar, Prentice Hall College Div, 4th Sub Edition, 1998. 3. Microprocessors and Interfacing, Douglas V Hall, Glencoe McGraw-Hill, 2nd Sub Edition, 1991.

Course Code:0714 02 CSE 5245	**Year: First**	**Term: Second**
Course Title: Advanced Computer Architecture		
Course Status: Optional/Elective		
Credit:3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide a strong foundation to understand advanced computer system architecture and to apply these insights & principles in future computer designs. The course is structured around the three primary building blocks of general-purpose computing systems: processors' working mechanism in both hardware & software level, memory hierarchy & management, and parallel processing.	

Course Contents		CLOs
Section A		
1	Classification and addressing modes, Operands and Operations for Media and signal processing, instructions for control flow, encoding an instruction set.	1
2	Pipelined and Superscalar processors, Data hazards, Dynamic scheduling, Branch prediction, Hardware based speculation, Thread level parallelism. ILP with software approaches: Compiler	2

	Techniques, static branch prediction, static multiple issue, advanced compiler support for ILP. Multithreading.	
3	Basic Techniques of Integer Arithmetic, Floating-point Arithmetic, speeding up Integer Addition, Speeding up Integer Multiplication and Division. Memory technology, RAIDs, organization for improving performance.	1, 3, 5
Section B		**CLOs**
1	Virtual memory and protection, Cache organization, reducing cache miss rate and penalty, Symmetric shared memory architectures, Cache coherence protocols, Distributed shared memory architectures, Synchronization, Models for memory consistency.	1, 4
2	Busses, Performance measures, Designing I/O system, Reliability, Dependability and Availability. Interconnection Networks- Practical issues, Network on chip, Designing cluster. Advanced RISC, CISC and Embedded processors architectures.	3, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	To **illustrate** understanding of the setups required in the software level in order to communicate with processors.	2
	CLO2	To **demonstrate** understanding on achieving parallel programming for both thread level and instruction level and **identify** limitations along with their possible solutions.	2
	CLO3	To **model** & **analyze** hardware designs for complex operations.	1, 5
	CLO4	To **explain** processors' memory structures and **examine** scopes for balance.	1, 2
	CLO5	To **interpret** and **model** connections of both outer layer and internal structures.	1, 5

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO2	Interactive lecture, Discussions, Problem solving	Quiz, Class Test, and Final Exam
CLO3	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO4	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam
CLO5	Interactive lecture, Discussions	Quiz, Class Test, and Final Exam

Learning Materials

Recommended Textbook	1. Computer Organization and Design: The Hardware/Software Interface, David A. Patterson, John L. Hennessy, Morgan Kaufmann, 5th Edition, 2013. 2. Computer Organization & Architecture Designing for Performance, Prentice Hall, 9th Edition, 2012. 3. Computer Organization and Design, P. Pal Chaudhuri, PHI Learning Private Limited, 3rd Edition, 2013.

Course Code: 0714 02 CSE 5250	**Year: First**	**Term: Second**
Course Title: Dissertation Part-I-M		
Course Status: Optional		
Credit: 5.00		
Prerequisite(s): None		
Rationale	This is a capstone course that is a multi-layered work that serves as a concluding academic and intellectual experience for students towards research work in Masters.	

Course Contents		**CLOs**
1	Read insights of a specific topic and the previous works done by others.	1, 2
2	Write the proposal of the thesis he/she is going to perform for Masters.	1, 2, 3
3	Present orally the proposal he/she prepares.	2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand and analysis others' research outcomes.	1, 2, 4, 6, 8
	CLO2	Implement effective solutions with cutting-edge technologies.	2, 3, 4, 8
	CLO3	Write effective report so that it will deliver the authors message effectively to the readers.	2, 3, 4, 5, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Interactive lecturing	Research paper reading, Programming solutions
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Programming solutions, Demonstration, Discussion
CLO3	Cooperative learning,	Report, Presentation

	Problem solving, Writing	

Learning Materials

Recommended Readings	**Text Book:** 1. How to Write a Better Thesis, Authors: David Evans, Paul Gruba, Justin Zobel, Publisher: Springer Science & Business Media, 2014, ISBN: 3319042866
Supplementary Readings	**Reference Book:** 1. How To Write Your First Thesis, Authors: Paul Gruba, Justin Zobel, Publisher: Springer, 2017, ISBN: 3319618547

Course Code: 0714 02 CSE 6150	**Year: Second**	**Term: First**
Course Title: Dissertation Part-II-M		
Course Status: Optional		
Credit: 15.00		
Prerequisite(s): 0714 02 CSE 5250		
Rationale	This course is the continuation of 0714 02 CSE 5250. In this course, students will complete the study/work started in the previous term under 0714 02 CSE 5250 course. This is a capstone course that is a multi-layered work that serves as a concluding academic and intellectual experience for students towards research work in Masters.	

Course Contents		**CLOs**
1	Read insights of a specific topic and the previous works done by others.	1, 2
2	Write the proposal of the thesis he/she is going to perform for Masters.	1, 2, 3
3	Present orally the proposal he/she prepares.	2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand and analysis others' research outcomes.	1, 2, 4, 6, 8
	CLO2	Implement effective solutions with cutting-edge technologies.	2, 3, 4, 8
	CLO3	Write effective report so that it will deliver the authors message effectively to the readers.	2, 3, 4, 5, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing	Research paper reading, Programming solutions
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Programming solutions, Demonstration, Discussion
CLO3	Cooperative learning, Problem solving, Writing	Report, Presentation

Learning Materials

Recommended Readings	**Text Book:** 1. How to Write a Better Thesis, Authors: David Evans, Paul Gruba, Justin Zobel, Publisher: Springer Science & Business Media, 2014, ISBN: 3319042866
Supplementary Readings	**Reference Book:** 1. How To Write Your First Thesis, Authors: Paul Gruba, Justin Zobel, Publisher: Springer, 2017, ISBN: 3319618547

Course Code: 0714 02 CSE 6130	**Year: Second**	**Term: First**
Course Title: Project		
Course Status: Optional		
Credit: 6.00		
Prerequisite(s): None		
Rationale	This is a capstone course that is a multi-layered work that serves as a concluding academic and intellectual experience for students towards project work in real life.	

	Course Contents	CLOs
1	Read insights of a specific topic and the previous works done by others.	1, 2
2	Write the proposal of the thesis he/she is going to perform for Masters.	1, 2, 3
3	Present orally the proposal he/she prepares.	2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand and analysis others' research outcomes.	1, 2, 4, 6, 8
	CLO2	Implement effective solutions with	2, 3, 4, 8

		cutting-edge technologies.	
	CLO3	Write effective report so that it will deliver the authors message effectively to the readers.	2, 3, 4, 5, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing	Research paper reading, Programming solutions
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Programming solutions, Demonstration, Discussion
CLO3	Cooperative learning, Problem solving, Writing	Report, Presentation

Learning Materials

Recommended Readings	**Text Book:** 1. How to Write a Better Thesis, Authors: David Evans, Paul Gruba, Justin Zobel, Publisher: Springer Science & Business Media, 2014, ISBN: 3319042866
Supplementary Readings	**Reference Book:** 1. How To Write Your First Thesis, Authors: Paul Gruba, Justin Zobel, Publisher: Springer, 2017, ISBN: 3319618547

Course Code: 0714 02 CSE 6140	**Year: Second**	**Term: First**
Course Title: Internship		
Course Status: Optional		
Credit: 6.00		
Prerequisite(s): None		
Rationale	This is a capstone course that is a multi-layered work that serves as a concluding academic and industrial experience for students in real life.	

	Course Contents	CLOs
1	Students will solve real life ICT related problems through academic and industrial collaboration.	1, 2
2	Write a reports based on the work and experience earned from the industry during intern period.	1, 2, 3
3	Present orally the synopsis of the report.	2, 3

Course	Upon completion of this course the students	**Mapping with**

Learning Outcomes (CLOs)	will be able to:		**PLOs**
	CLO1	Understand and analysis others' research outcomes.	1, 2, 4, 6, 8
	CLO2	Implement effective solutions with cutting-edge technologies.	2, 3, 4, 8
	CLO3	Write effective report so that it will deliver the authors message effectively to the readers.	2, 3, 4, 5, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Interactive lecturing	Research paper reading, Programming solutions
CLO2	Interactive lecturing, Visualization, Discussions, Cooperative learning	Programming solutions, Demonstration, Discussion
CLO3	Cooperative learning, Problem solving, Writing	Report, Presentation

Learning Materials

Recommended Readings	
Supplementary Readings	

20. Grading and Evaluation

20.1 Grading Scale

a) Letter Grades and corresponding Grade Points will be awarded following provisions shown below:

Numerical Grade	Letter Grade	Grade Point
80% or above	A+ (A plus)	4.00
75 to less than 80%	A (A regular)	3.75
70 to less than 75%	A- (A minus)	3.50
65 to less than 70%	B+ (B plus)	3.25
60 to less than 65%	B (B regular)	3.00
55 to less than 60%	B- (B minus)	2.75
50 to less than 55%	C+ (C plus)	2.50
45 to less than 50%	C (regular)	2.25
40 to less than 45%	D	2.00
Less than 40%	F	00
Incomplete	I	
Withdrawn	W	
Continuation (for the project, thesis design, etc. course)	X	

20.2.1 Evaluation of Theory and Sessional Courses

a) All theory courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance and Class Participation	10
2	Continuous Assessments	30-40
3	Term Final Examination	50-60
	Total	**100**

b) All sessional courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance and Class Participation	10
2	Sessional Assessments	60
3	Viva Voce	30
	Total	**100**

c) The basis for awarding marks for class attendance and participation will be as follows:

Attendance & Participation	**Marks**
90% or above	10
85 to below 90%	9
80 to below 85%	8
75 to below 80%	7
70 to below 75%	6
65 to below 70%	5
60 to below 65%	4
Below 60%	0

d) The continuous assessments (30 to 40 marks) of theory courses may be conducted in the form of written class examinations, assignments, home-works, presentations, quizzes, viva voce, mid-term, etc. For any theoretical course, there shall be at least four assessments. Section best (A & B) assessments shall be counted. The course teachers must submit the continuous assessment and sessional assessment mark sheets to the Chair of the Examination Committee before the starting of the Term final examination. The remaining 50 to 60 marks will be allocated for the term final examination.

e) A student who fails in any course(s) in the Term final examinations or who registered for the course(s) but did not sit for the examination, the concerned course(s) will be considered as retake course(s).

f) A student retaking theory course(s) for clearing/passing or improvement must appear at
the mid-term (if any) and Term final examinations. A student may attend continuous assessments also on the written approval of the Discipline Head; otherwise, the marks of continuous assessments will be maintained from the student's previous records. The marks of attendance will be carried forward from earlier Term. The obtained grade will be downgraded in case of retaking course(s).

20.2.2 Evaluation of Capstone Courses

20.2.2.1 Dissertation under Mixed-Mode

a) There will be two components of the Dissertation, namely Dissertation Part-I-M in one Term for proposal development, and Dissertation Part-II-M in another term for completing the Dissertation. The total credit for the Dissertation will be 20.00 credits. The credit allocation for proposal development (Dissertation Part-I-M) and dissertation (Dissertation Part-II-M) parts will be 8.00 credit sand 12.00 credits, respectively.

b) Dissertation Part-I-M will usually commence in the Master's first-year second-term and Dissertation Part-II-M in the second-year first-term (final Term).

c) The final evaluation of the Dissertation Part-II-M will be made at the end of the final Term. However, the evaluation of the Dissertation Part-I-M will be done in the corresponding Term.

d) A Dissertation (both proposal and Dissertation) will be evaluated out of 100 marks.

Marks distribution of Dissertation Part-I-M		
(i)	Assessment of Supervisor	30 Marks
(ii)	Proposal Presentation	70 Marks
Marks distribution of Dissertation Part-II-M		
(i)	Assessment of Supervisor	20 Marks
(ii)	Dissertation Evaluation	50 Marks
(iii)	Defense (Oral examination)	30 Marks

20.2.2.2 Project under Mixed-Mode

a) A student undertaking a project work will register 6.00 credits usually in the second year first-term (final term) under the guidance of a Supervisor. Final evaluation of the project report will usually be made at the end of the final Term for the student.

b) A project will be evaluated out of 100 marks. Marks distribution of the project will be as follows:

(i)	Assessment of Supervisor	20 Marks
(ii)	Project Report Evaluation	50 Marks
(iii)	Defense (Oral examination)	30 Marks

20.2.2.3 Master's My Research Program

a) The students under 'Master's by Research' program have to register for four parts of the Dissertation as follows:

Serial No.	Course	Year	Term	Credit
(i)	Dissertation Part-I	I	I	8.00
(ii)	Dissertation Part-II	I	II	12.00
(iii)	Dissertation Part-III	II	I	12.00
(iv)	Dissertation Part-IV	II	II	15.00

b) Usually research topic selection, title, rationale, objective, research question, literature review, sampling, research design, experiment, survey, data/information collection, analysis, result, discussion, policy implication, limitation, reference, annex, etc. related various issues will be covered (as applicable) under these four parts. The curriculum of the concerned program will provide a detailed description of coverage, objective, learning outcome, credit, etc., of these four parts.

c) A student registered for Dissertation will undertake research under the guidance of a Supervisor and a Co-supervisor (if necessary).

d) Final evaluation of the Dissertation Part-IV will be made at the end of the final Term. However, the Dissertation Part-I, II, and III will be evaluated in the corresponding terms.

e) A Dissertation (Part I-IV) will be evaluated out of 100 marks.

Marks distribution of Dissertation Part I, II, III		
(i)	Assessment of Supervisor	30 Marks
(ii)	Proposal Presentation	70 Marks
Marks distribution of Dissertation Part IV		
(i)	Assessment of Supervisor	20 Marks
(ii)	Dissertation Evaluation	50 Marks
(iii)	Defense (Oral examination)	30 Marks

f) A student must publish (or at least accepted for publication) an article/paper in a Peer-reviewed journal or a peer-reviewed conference paper in order to complete 'Master's by Research' Degree.

20.3Withdrawal from a Term

a) If any student cannot complete the Term Final Examination due to severe illness or serious accident, he/she may apply to the Dean through the Head of the concerned Discipline for total withdrawal from the Term within eight working days after the Term Final Examination. However, he/she may choose not to withdraw from any sessional course if the grade obtained in such a course is C or better. A medical certificate endorsed by the Chief Medical Officer of the University must support the application. The Dean of the concerned School will decide on such an application and inform the Academic Council. If a student is allowed to withdraw from a Term, he/she will have to register as fresh from the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.4 Absence in a Term

A student may be absent from continuous assessments (quizzes/class test/field works, etc.) during the Term. Such absences will naturally reduce points/marks, which count towards the final grade. Absence in the Mid Term (if any) and the Term Final Examination will result in 'F' grade.

A student who has been absent for short periods, up to a maximum of three weeks due to illness, should request the Course Teacher or Program Coordinator to makeup continuous assessments immediately on returning to the class. A medical certificate should support such request from the Chief Medical Officer of Khulna University. The medical certificate issued by registered medical practitioners (with the registration number shown explicitly on the certificates) and endorsed by the Chief Medical officer of the University will also be acceptable only in those cases where the student has valid reasons for his absence from the University.

20.5 Course Adjustment Procedure

A student will have the option to add or drop course(s) from his/her registration list within fifteen working days from the beginning of classes. This can be done with the advice of the concerned Program Coordinator and consent of the Discipline Head. Adjustment of initially registered courses in any Term can be made by duly filling in the Adjustment Form. The Registrar's office will do the needful.

20.7 Limit on the Credits to be Taken in a Term

Discipline Head may allow a student to register up to a maximum of 25 credits if recommended by the Program Coordinator. However, there is no minimum credit limit per Term in Master's level study.

20.7 Registration for Improvement

If any student gets a 'D' to 'C+' grade in any course, s/he may be allowed to repeat that course to improve the grade. The previous grade will be replaced from the grade sheet in such a case.

Approval Records	
Approving Authority	Date of Approval
Curriculum Committee of the Discipline	30 August 2022
Executive Committee of the School	
BOAS (if applicable)	
Academic Council	
Syndicate (if applicable)	

Contributors

Concerned Committee of the Discipline/POE (if applicable)		
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1.	Dr. Md. Rafiqul Islam, Professor, CSE Discipline, KU	Member
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17.	Dr. Md. Mamun-Ur-Rashid, Professor, CSE, University of Dhaka	Expert Member

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3.	Md. Tarikul Islam Khan	DGM, Metro BTCL, Khulna
4.	Md. Mahmud Ul Hasan Rana	Systems Sales Manager Oracle
5.	A Z M Anwaruzzamn	Executive Engineer, PDB, Mymensingh

References

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IQAC 2022. Template of Outcome-based Curriculum, Institutional Quality Assurance Cell (IQAC), Khulna University. pp. 1-18.

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