PROGRAM CURRICULUM

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Graduate Program

M.Sc./ M. Engg. in Computer Science and Engineering

LEADING UNIVERSITY

Prepared for:
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LEADING UNIVERSITY

Faculty of Modern Science

Department of Computer Science & Engineering (CSE)

M.Sc. / M. Engg. in Computer Science & Engineering

Background

A computer system is a means to solve some of today's existing problems. The problems in the developing world are more pressing than the problems of the developed world. How well a computer system has solved a problem depends on how well the concerned professional has tailored the hardware + software to suit the needs of the situation at hand.

Introduction

The term professional is being applied to the persons who setup the hardware, develop or tailor the software and implement a computer system as a solution to a need. To do this effectively, the professional has not only to understand the nature of hardware and software, but has, to some extent, be conversant with the problem to which the solution is being applied. The problem would generally be a business related problem, but could also be a technological, social or developmental one.

Today, a computer system has the potential of offering solutions such as e-education, e-learning, e-commerce added to the generally accepted e-mail as a means of fast communication. These are recent solutions provided by the subject of Computer Science. The professional has to have the ability to evaluate the tools provided by Computer Science as solutions to today's real world problems.

Objective of the Degree

The objective of the degree is to produce a well-informed and well-balanced graduate who can use Computer Science and Engineering tools to solve real world problems. At Masters level, they would be trained in research methodology, so that they can contribute towards creation of new knowledge.

Degree offering Department

Our degree-offering department is the Department of Computer Science and Engineering, which is under Faculty of Modern Science.

Duration of a semester

Proposed academic programs will run on semester system (15 weeks per academic semester excluding exams). Credits have been based on the number of hours of lectures that need to be delivered in a week. One lecture per week throughout the semester means 1 Credit Hour. A course is normally delivered 3 hours per week which is equivalent to 3 Credit Hours. For 1 credit theory course will be equal to minimum 15 hours of actual lecture time per semester of a semester system. For 1 credit Sessional course minimum of 30 hours of actual Sessional works per semester of a semester system will be required. That means **theory classes will have a minimum duration of 1hour for 1 credit hour and each Sessional class will have a minimum duration of 2-hours for 1 credit hour and 3 hours for 1.5 credit hour**. Course credit is assigned according to the number of in-class contact hours associated with the course.

Admission Requirements:

- Students having a minimum of 2nd class /2.5 CGPA (out of 4) in 4-year Bachelor degree in engineering discipline from recognized university can apply.

- There shall be two categories of student, namely, **Category 1**: Computer Science, Computer Science & Engineering, ICT or any other program where the term computer is present in program name. **Category 2**: Students from any other Engineering disciplines which are not mentioned in **Category 1**.

Grading System

All course work is graded according to a unified grading system as shown in the following chart.

Numerical Grade	Letter Grade		Grade Point
80% and 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	(C regular)	2.25
40% to less than 45%	D		2.00
Less than 80%	F		0.00

***Uniform grading system is provided by UGC**

Grade Points

A student's semester grade point average is determined by dividing the total number of grade points by the total number of credits attempted. Grade point totals are calculated by multiplying the number of credit of a course by the number of points for the corresponding grade received. A student's grade point average will be determined by dividing the total number of grade points by the total number of credit attempted with the exception of courses in which marks of "I" are received.

Course Evaluation:

There will be **one midterm worth 30% and final examination worth 40%. 5% for class attendance, 10% for tutorials, 5% for viva, 10% for quizzes, assignments, and presentations.** Any missed exam/test will earn zero (0). Academic dishonesty, such as Misbehaver in class, copying exam/test or letting another student copy may result "F" grade in the course.

Policy

- For the degree of M. Sc. a student must earn a minimum of 36 credit hours including a thesis for which 18 credit hours shall be assigned.
- For the degree of M. Engg. a student must earn a minimum of 36 credit hours including a project for which 6 credit hours shall be assigned.
- Each course will consist of no less than 100 marks or points. There are no fixed criteria in terms of test scores. The allocation of 100% marks/points will be taken according to the marks distribution mentioned above.
- The nature of questions should be of varied nature such as MCQ, short type, Broad type, Case Study; Specific problems etc. or in any other form as the tutors deem it necessary to judge the comprehensive study as well as the merit of the students.
- Questions for semester final will be submitted in two sets in different form at least two weeks ahead of Exam dates as these questions will be sent to Moderation Board.
- Duration of the Mid-Term Tests from 1 to 1½ hour and Final Examinations may be 2 to 3 hours respectively depending on the nature of questions.

- According to the schedule of examinations final examinations are held in all courses upon the completion of each semester's work. No one is to be excused from the final examinations.
- Course Instructor/Tutor shall conduct their respective tests and Exams. Question papers are to be taken back from the students at the end of each exam.
- Students must register for a minimum of 9 credit hours and a maximum of 15 credit hours per semester.
- For the Project or Thesis, the supervisor will give an overall assessment which will count as 30% of the total marks. Evaluation of the report by two external examiners, who is not involved in supervision / co-supervision will count as another 30% of the marks. The remaining 40% will come from the presentation and viva voce conducted by the examination committee. During viva-voce examination the supervisor or co-supervisor, if present, will not participate in marking.

PROJECT/THESIS SUPERVISION POLICY:

1. Purpose

This policy was created with the following objectives:

(1) To explain the criteria for the appointment of the supervisor and the role and responsibilities of the supervisor to the candidate in the research mode and the coursework and research modes.
(2) To ensure the quality of supervision is assured and that the research produced by the candidate is consistent with the mission and vision of the University.
(3) As a guide for academic staff and candidates in the Leading University in executing the responsibilities as a supervisor and research candidate.

2. Appointment of Supervisor

The appointment of a supervisor must meet the following criteria:

(1) It is encouraged to appoint at least two (2) supervisors for each candidate. If only one supervisor is appointed, the supervisor must have the experience of supervising until graduation at least two (2) candidates.
(2) The appointed supervisor must have a minimum qualification equivalent to the degree or at par with the program registered by the candidate.
(3) The appointment of a Supervisor shall take into account the research skills and experiences which are consistent with the research field of the candidate.
(4) Supervisors suggested by prospective candidates, are given priority to supervise, except in cases where the Department feels that other supervisors are more qualified to supervise.
(5) Academic staff on sabbatical leave may be allowed to supervise until the end of the leave, provided the leave does not affect the candidate's supervision. However, based on some specific reasons, the Supervisor may apply to not

supervise the candidate while on leave and the decision is based on the discretion of the Department.

(6) For academic staff who will be coming to the end of their services, the Academic Committee should ensure that a replacement supervisor is appointed at least six (6) months prior to the end of the service date of the initial supervisor so that both of them can co-supervise without affecting the progress of the candidate's research.

(7) For academic staff have left the service in Leading University but is still doing academic work elsewhere, they may be appointed as co-supervisor and the number of candidates supervised shall be limited to five (5) persons, where the candidates must be in their final stage of their studies.

(8) Appointment of an external party (either academic or non-academic) as co-supervisors can be considered if the external party is able provide research facilities and the expertise which will in turn assist the candidates in their research.

(9) If the department would like to appoint a supervisor who is not in compliance with all the criteria of appointment specified in the policy, the department shall submit a letter of application together with a strong justification to the Head of the Department for consideration and approval.

(10) Appointment of supervisors shall be managed by the Department in compliance with all the criteria specified in this policy. Appointment made shall take into account the space, resources and expertise to support and assist candidates, with their research.

(11) If the appointment of a new supervisor is required for some reason, the appointment shall be made according to merit and this case is considered as a special case. This case cannot be referred to and be an example or a precedent for a case to come.

(12) In the event of problems of supervision between supervisor and candidate, the department should address this problem. If the problem cannot be resolved, the matter may be submitted to the Head of the department.

3. Ratio between Supervisor and Candidate

(1) The maximum ratio for candidates to obtain quality supervision are as follows: -

Professor	1:25
Associate Professor	1:20
Assistant Professor	1:15
Lecturer	1:10

(2) Department may approve a higher maximum number of candidates provided that supervisor has shown excellent supervision performance.

(3) Department can also set a different maximum number of students from above to meet the requirements of relevant professional bodies.

(4) In calculating the supervisory workload, three (3) candidates of the mixed-mode is equal to two (2) candidates of the research mode.

4. Change of Supervisor

Change of supervisor can be implemented as follows:

(1) If there is strong justification and excuse, the candidate may apply to change the supervisor, not more than once during the period of candidature.

(2) If there is a supervisor who did not perform the supervisory duties satisfactorily, the head of the department may appoint any other qualified academic staff to replace the said supervisor.

5. Family Links

(1) Supervisors appointed shall not have a close family link to the candidate.
(2) Both the appointed supervisors also must not have any family relationship with each other.

6. Role and Responsibilities of the Supervisor

The appointed supervisor shall exercise his/her role and responsibilities as set out in Appendix A.

7. Role and Responsibilities of the Candidate

The candidate shall also be responsible for the candidature and research throughout their status as a student in Leading University as set out in Appendix B.

Course Numbering System

Course numbers in the University system indicate course level:
50x ..... No credit
5xx ..... Graduate level—open only to students registered in the Graduate School.

** The second digit stands for the usual semester the student should be advised, third digit stands for subject code, odd numbers are for theory courses and even numbers are for sessional.

Symbols and Abbreviations
Prefixes .....Three-letter department designator (e.g., CSE for Computer Science & Engineering).

Credit Hours
The areas and titles of the courses for each year are given on the next page. The curriculum has been based on the semester system.

Credits have been based on the number of hours of lectures that need to be delivered in a week. One lecture per week throughout the semester means 1 Credit Hour. A course is normally delivered 3 hours per week which is equivalent to 3 Credit Hours. The student will have to register for at least 9 credits and a maximum of 15 credits per semester.

Student Category 1:

Summary of Courses: M.Engg. in CSE:

Types of Courses	No. of Courses	Credit Hours
Core Courses: Total 15 credit hours	5	15
Elective: Total 15 credit hours	5	15
Project (Part I+II)	1	06
Total		**36 credit hours**

Summary of Courses: M.Sc. in CSE:

Types of Courses	No. of Courses	Credit Hours
Core Courses: Total 15 credit hours	5	15
Elective: Total 03 credit hours	1	03
Thesis (Part I+II)	1	18
Total		**36 credit hours**

Student Category 2:

Summary of Courses: M. Engg. in CSE:

Types of Courses	No. of Courses	Credit Hours
Basic CSE Courses: Total 18 credit hours	6	18
Core Courses: Total 15 credit hours	5	15
Elective: Total 15 credit hours	5	15
Project (Part I+II)	1	06
Total		**54 credit hours**

** 1 Basic CSE Course waiveable

Summary of Courses: M.Sc. in CSE:

Types of Courses	No. of Courses	Credit Hours
Basic CSE Courses: Total 18 credit hours	6	18
Core Courses: Total 15 credit hours	5	15
Elective: Total 03 credit hours	1	03
Thesis (Part I+II)	1	18
Total		**54 credit hours**

** 1 Basic CSE Course waiveable

List of Courses (Student Category 1)

Core Courses: (Any five courses to be taken)

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 511	Digital Image Processing	3	3
CSE 513	Advanced Computer Networking	3	3
CSE 515	**Research Methodology**	**3**	**3**
CSE 517	Advanced Machine Learning	3	3
CSE 519	**Advanced Software Engineering**	**3**	**3**
MAT 511	**Advanced Probability, Stochastic Process and Optimization**	**3**	**3**
CSE 521	Data Warehousing & Data Mining	3	3

Elective Courses: (Any 1 course to be taken)

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 551	Pattern Recognition	3	3
CSE 553	Wireless Networks	3	3
CSE 555	**Computer Security & Cryptography**	**3**	**3**
CSE 557	Cloud Computing	3	3
CSE 559	Natural Language Processing	3	3
CSE 561	Neural Networks & Fuzzy Systems	3	3
CSE 563	Advanced Algorithm & Complexity Analysis	3	3
CSE 565	Distributed and Parallel Computing	3	3
CSE 567	Optical Wireless Communication	3	3
CSE 569	Software Testing & Quality Assurance	3	3
CSE 571	Big Data Analytics	3	3
CSE 573	Cybercrime and Intellectual Property Law	3	3

Thesis/ Project:

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 520	Project (Part-I)	3	6
CSE 530	Project (Part-II)	3	6
CSE 520	Thesis (Part-I)	9	18
CSE 530	Thesis (Part-II)	9	18

List of Courses (Student Category 2)

Basic CSE Courses (Any six courses to be taken):

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 531	**Programming with C**	3	3
CSE 533	Data Structure	3	3
CSE 535	**Computer Network**	3	3
CSE 537	Object Oriented Programming	3	3
CSE 539	Database Management System	3	3
CSE 541	Operating System	3	3
CSE 543	Computer Architecture	3	3
CSE 545	Computer Algorithm	3	3

Core Courses:

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 511	Digital Image Processing	3	3
CSE 513	Advanced Computer Networking	3	3
CSE 515	Research Methodology	3	3
CSE 517	Advanced Machine Learning	3	3
CSE 519	Advanced Software Engineering	3	3
MAT 511	Advanced Probability, Stochastic Process and Optimization	3	3
CSE 521	Data Warehousing & Data Mining	3	3

Elective Courses:

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 551	Pattern Recognition	3	3
CSE 553	Wireless Networks	3	3
CSE 555	Computer Security & Cryptography	3	3
CSE 557	Cloud Computing	3	3
CSE 559	Natural Language Processing	3	3
CSE 561	Neural Networks & Fuzzy Systems	3	3
CSE 563	Advanced Algorithm & Complexity Analysis	3	3
CSE 565	Distributed and Parallel Computing	3	3
CSE 567	Optical Wireless Communication	3	3
CSE 569	Software Testing & Quality Assurance	3	3
CSE 571	Big Data Analytics	3	3
CSE 575	Cybercrime and Intellectual Property Law	3	3

Thesis/ Project:

Course Code	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE 520	Project (Part-I)	3	6
CSE 530	Project (Part-II)	3	6
CSE 520	Thesis (Part-I)	9	18
CSE 530	Thesis (Part-II)	9	18

Semester-wise Course Distribution

(Category 1)
M. Engg. in CSE

First Semester (1st Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
MAT 511	Advanced Probability, Stochastic Process and Optimization	3	3
CSE ***	Core Course-II	3	3
CSE ***	Core Course-III	3	3
CSE ***	Core Course-IV	3	3
	Total	12	12

Second Semester (1st Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Core Course-V	3	3
CSE ***	Elective Course I	3	3
CSE ***	Elective Course II	3	3
CSE 520	Project (Part-I)	3	6
	Total	12	15

Third Semester (2nd Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Elective Course III	3	3
CSE ***	Elective Course IV	3	3
CSE ***	Elective Course V	3	3
CSE 530	Project (Part-II)	3	6
	Total	12	15

(Category 1)
M. Sc. in CSE

First Semester (1st Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
MAT 511	Advanced Probability, Stochastic Process and Optimization	3	3
CSE ***	Core Course-II	3	3
CSE ***	Core Course-III	3	3
CSE ***	Core Course-IV	3	3
	Total	12	12

Second Semester (1st Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Core Course-V	3	3
CSE 520	Thesis (Part-I)	9	18
	Total	12	21

Third Semester (2nd Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Elective Course I	3	3
CSE 530	Thesis (Part-II)	9	18
	Total	12	21

(Category 2)
M. Engg. in CSE

First Semester (1st Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Basic CSE Course I	3	3
CSE ***	Basic CSE Course II	3	3
CSE ***	Basic CSE Course III	3	3
CSE ***	Basic CSE Course IV	3	3
CSE ***	Basic CSE Course V	3	3
CSE ***	Basic CSE Course VI	3	3
	Total	18	18

Second Semester (1st Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
MAT 511	Advanced Probability, Stochastic Process and Optimization	3	3
CSE ***	Core Course-II	3	3
CSE ***	Core Course-III	3	3
CSE ***	Core Course-IV	3	3
	Total	12	12

Third Semester (2nd Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Core Course-V	3	3
CSE ***	Elective Course I	3	3
CSE ***	Elective Course II	3	3
CSE 520	Project (Part-I)	3	6
	Total	12	15

Forth Semester (2nd Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Elective Course III	3	3
CSE ***	Elective Course IV	3	3
CSE ***	Elective Course V	3	3
CSE 530	Project (Part-II)	3	6
	Total	12	15

(Category 2)
M. Sc. in CSE

First Semester (1st Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Basic CSE Course I	3	3
CSE ***	Basic CSE Course II	3	3
CSE ***	Basic CSE Course III	3	3
CSE ***	Basic CSE Course IV	3	3
CSE ***	Basic CSE Course V	3	3
CSE ***	Basic CSE Course VI	3	3
	Total	18	18

Second Semester (1st Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
MAT 511	Advanced Probability, Stochastic Process and Optimization	3	3
CSE ***	Core Course-II	3	3
CSE ***	Core Course-III	3	3
CSE ***	Core Course-IV	3	3
	Total	12	12

Third Semester (2nd Year 1st Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Core Course-V	3	3
CSE 520	Thesis (Part-I)	9	18
	Total	12	21

Forth Semester (2nd Year 2nd Semester)

Course No.	Course Title	Credit Hours	Hours / Week Theory and Lab
CSE ***	Elective Course I	3	3
CSE 530	Thesis (Part-II)	9	18
	Total	12	21

Details Course Syllabus (OBE)

CSE 511 DIGITAL IMAGE PROCESSING
Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: This course aims to introduce the principles of digital image processing and to develop students' knowledge from basic signal processing techniques to advanced image processing and analysis systems

Objectives:

The course contributes of the following program learning outcomes:

1. Fundamental technologies for digital image, compression, analysis, and processing
2. Gain understanding of algorithm, analytical tools, and practical implementations of various digital image applications.

Learning Outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Students should be able to: Learn the building blocks of a digital image processing system, and learn about the different types of image to be processed in the courses as well as the type of problems to be solved.	Digital Image Fundamentals: Fundamental steps in DIP, Components of digital image processing, elements of visual perception, Structure of the human eye, Image formation in the eye, Brightness adaptation and discrimination, light, Image sensing and acquisition, image formation model, definition and some properties of two dimensional system, Discrete 2D convolution, 2D discrete Fourier transform and its properties, optical and modulation transfer function, Spectral density function. Sampling and quantization of images, Two dimensional sampling theory, representation of digital image, Spatial and gray level resolution, zooming and shrinking, some basic relationships between pixels.	Lecture, Q/A, PowerPoint Slides	Assignment, Quiz
Students should be able to: Learn the principles of image foundation, sampling, quantization and the human	Image Enhancement in the Spatial Domain: Gray Level Transformations, Piecewise linear transformation,	Lecture, Q/A, PowerPoint Slides	Assignment

visual system, which will allow them to investigate specific image processing techniques later on.	Histogram Processing, Enhancement Using Arithmetic/Logic Operations. Basics of Spatial Filtering, Smoothing and Sharpening Spatial Filters, Use of first order and second order derivative in enhancement.		
Students should be able to: Lean image intensity transformations and spatial filtering for the purpose of image enhancement in the spatial and frequency domains.	Image Enhancement in the Frequency Domain: Two dimensional Fourier Transform, properties of frequency domain, correspondence between filtering in spatial and frequency domain, Smoothing and Sharpening frequency domain filters, Homomorphic Filtering.	Lecture, Q/A, PowerPoint Slides	Assignment
Students should be able to: Learn image restoration in the spatial and frequency domains. Students learn how to deal with different types of noise models and degradation processes. Then they learn about inverse filtering and wiener filtering	Image Restoration: Model of the Image Degradation/Restoration Process, Noise Models, Noise reduction in spatial domain and frequency domain, Inverse filtering, Wiener filtering.	Lecture, Q/A, PowerPoint Slides	Assignment
Students should be able to: Learn about color spaces and color image processing and how to restore and enhance color images and different color spaces.	Image Compression: Fundamentals of Image Compression, Image compression models, concepts of Information Theory, Fundamental coding theorems, Estimation of entropy, Variable length coding, Huffman coding, Near optimal variable length coding, Near optimal variable length coding, Arithmetic coding, constant area coding, run length coding, image compression standards (JPEG, JPEG2000).	Lecture, Q/A, PowerPoint Slides	Project work
Students should be able to: Learn about image detection and discontinuities, edge linking and boundary detection. They also know about diriment types of image segmentation techniques.	Image Segmentation: Detection of Discontinuities (point, line edge), Edge Linking and Boundary Detection, Thresholding, Basic global Thresholding, Adaptive Thresholding, Region-Based Segmentation, region growing, splitting and merging.		

RECOMMENDED BOOKS AND REFERENCES

Text books:

- *Gonzalez Rafael C and Woods Richard E, Digital Image Processing, 3rd Edition, Prentice Hall, 2008. (TA1632.G643 2008)*

Recommended text books:

- Pratt William K, Digital Image Processing: PIKS Scientific Inside, 4th Edition, John Wiley, 2007. (TA1632.P917 2007)
- Pitas Ioannis, Digital Image Processing Algorithms and Applications, John Wiley, 2000. (TA1637.P681)
- Jain Anil K, Fundamentals of Digital Image Processing, Prentice-Hall, 1989. (TA1632.J25)

CSE 513 ADVANCED COMPUTER NETWORKING

Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: This is a graduate level course on computer networking focusing on advanced topics and is a must for anyone interested in doing research in computer networks. The course consists of both a reading/lecture/discussion component and a project component. We will read at least 50 research papers on most recent topics of computer networking. This class examines the current and emerging research topics in computer networking. Topics covered include network protocols, network measurement, Internet routing, peer to peer networks, network security, wireless and sensor networks. Significant emphasis will be put on security and network management issues related to computer networks, as these are becoming increasingly important given the growing number attacks and complexity of networks.

Objectives:

By the end of the semester, students should develop the following skills:

1. This course provides an in-depth examination of the fundamental concepts and principles in communications and computer networks. Topics include: queuing analysis, ATM, frame relay, performance analysis of routings, and flow and congestion controls.
2. The "physical edge" of the Internet, i.e., access networks. In particular, we will examine how proliferation of mobile, wireless access techniques affects, choice of algorithms, protocols and their implementations.
3. To become familiar with the state of the art in networking research: network architecture, protocols and systems.
4. To gain some practice in reading research papers and critically understanding the research of others.
5. To gain experience with network programming using state-of-the-art research platforms.
6. To investigate novel ideas in networking through a semester-long research project.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
This portion explores congestion control more deeply. In doing so, it is important to	• Internet Congestion	Lecture, Q/A, Multimedia Slides,	Quiz and Assignments

understand that the standard TCP's strategy is to control congestion once it happens, as opposed to trying to avoid congestion in the first place. The algorithms will help to take the decisions. There will be in details description of Open loop and Closed loop System. ● Internet routers, lower-layer switches, end-host operating systems, device drivers, and many types of additional middle boxes include memory buffers in which they implement queues to hold packets that require processing or otherwise need to wait for forwarding to the next hop. The Active Queue Management and Packet Scheduling working group (AQM) works on algorithms for managing queues. ● The primary applications of XCP are measurement and calibration of internal ECU parameters. Here, the protocol offers the ability to acquire measured values event synchronous to processes in ECUs. This ensures consistency of the data between one another.	Control: Source Algorithms ● AQM ● Unified Method e.g. XCP	White Board	
● Came to know about the Intrusion Detection System (IDS) which is a network security technology originally built for detecting vulnerability exploits against a target application or computer. An intrusion detection system (IDS) is a type of security software designed to automatically alert administrators when someone or something is trying to compromise information system through malicious activities or through security policy violations. It will help to know the basic security mechanisms. Define the terms speedup and efficiency. ● In this section students came to know about the different types of	Security ● Intrusion ● Detection ● DDoS Attacks	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

DoS attacks. A distributed denial-of-service (DDoS) attack is an attack in which multiple compromised computer systems attack a target, such as a server, website or other network resource, and cause a denial of service for users of the targeted resource.			
• Students will come to know ad-hoc network which is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. • They will learn about MANET which is a mobile ad hoc network (MANET), also known as wireless ad hoc network or ad hoc wireless network is a continuously self-configuring, infrastructure-less network of mobile devices connected wirelessly. • Also came to know about Wireless Sensor Networks. WSN is a wireless network that consists of base stations and numbers of nodes (wireless sensors).These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and co-operatively pass data through the network to a main location as shown in the figure.	• Ad-hoc networks, • MANets • Wireless sensor networks (Routing in ad-hoc networks)	Lecture, Q/A, Multimedia Slides, White Board	
• Students will learn about the distributed systems .Grid computing is a distributed architecture where many computers are connected to resolve any given problem. In grid computing is used, all servers or personal computers are linked over a common network using WAN and independent tasks are assigned to each.	• Grid & Cloud Computing (Google File Systems and Data Centers; Cloud Computing)	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

● Learn to utilize the online storage system and deal with different storage related challenges. Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user.			
● Came to learn about the details working principles in data centers and the different techniques to store data. A data center is a facility that centralizes an organization's IT operations and equipment, as well as where it stores, manages, and disseminates its data.	● Data Centers and Data Center Networking	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
● Students become familiar with the most recent version of the Internet Protocol (IP), the communications protocol that provides an identification and location system for computers on networks and routes traffic across the Internet. Came to know different conversations, necessity and different issues of IPv6.	● IPv6	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
● Students came to know about Multi-Protocol Label Switching. It is a mechanism for routing traffic within a telecommunications network, as data travels from one network node to the next. MPLS can provide applications including VPNs (Virtual Private Networks), traffic engineering (TE) and Quality of Service (QoS). Besides they came to know about Flexible and efficient packet switching, Scale to high performance switch, virtual circuit network related issues.	● ATM and MPLS	Lecture, Q/A, Multimedia Slides, White Board	
● Game theory has been used extensively in wireless networks research to develop understanding of stable operation points for networks made of autonomous/selfish nodes. The nodes are considered as the strategic decision making. More formally, it is the study of mathematical models of conflict	● Game Theoretic Approaches for Communication Networks	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

players. Game theory is the study of and cooperation between intelligent rational decision-makers.			
• In this portion students came to know the techniques to maintain the quality of service. Quality of Service (QOS) is a suite of technologies used to manage bandwidth usage as data crosses computer networks. Its most common use is for protection of real-time and high priority data applications. Queues provide bandwidth reservation and prioritization of traffic as it enters or leaves a network device.	• Internet QoS: Integrated Service, Differentiated service	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
• Instruction will deliver to the students about different recent research issues and will let students know research inside.	• Research Methodology	Lecture, Q/A, Multimedia Slides, White Board	Presentations and Assignments

RECOMMENDED BOOKS AND REFERENCES

Required:
Computer Networking: A Top-Down Approach Featuring the Internet
by Jim Kurose and Keith Ross, Addison-Wesley.
ISBN: 0-201-61274-7

Other references:
The course will be based on a list of required and supplemental readings (research papers, articles, book chapters, and Internet RFCs). Some important links are given below:

- https://ieeexplore.ieee.org/Xplore/home.jsp
- https://www.springer.com/in
- https://www.sciencedirect.com/
- https://dl.acm.org/

Reference Book:

1. Computer Networks: A Systems Approach (4th Edition)
   by Larry Peterson and Bruce Davie. Morgan Kaufmann, 2003.
   ISBN: 1-55860-832-X
2. TCP/IP Sockets in C: Practical Guide for Programmers
   by Michael Donahoo and Kenneth Calvert. Morgan Kaufmann, 2003.
   ISBN: 1-55860-826-5

CSE 515 RESEARCH METHODOLOGY

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Meaning, Objectives and Motivation in Research, types of Research, Research Approaches, Research Process, Validity and Reliability in Research, Obstacles in accepting research. Problem Formulation, Hypothesis Formulation, types of Hypothesis, characteristics of Good Hypothesis. Meaning and Significance of Research Designs, Features of a good research design, types of research design, and contents of research design. Census vs. Sample. Steps in Sample Design, Determining the size of Sample. Sampling methods - Simple Random Sampling, Stratified Sampling, Systematic Sampling, Cluster Sampling, and Selective Sampling. Types of Data, Sources of Data, Primary and Secondary Data. Methods of collecting the data. Testing the validity of the data. Measurement and scaling techniques, errors in measurement, tests of sound measurement, scaling and scale construction techniques Steps in Questionnaire design, characteristics of a good questionnaire Presentation, Processing & Analysis and Interpretation of Data. Report Writing – layout of a Research Report, Characteristics of a good research report.

Intended Learning outcomes (ILOs)	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Identify some of the reasons for doing research. Know how research can be used to gather evidence to inform your practice.	Meaning of Research, Application and characteristics of research.	Lecture, Q/A,	
Learn the eight-step model for carrying out research	Research Approaches and Research Processes	Lecture, Q/A,	
The functions of the literature review in research. How to carry out a literature search. How to review the selected literature	Reviewing the Literature, Developing a theoretical framework.	Lecture, Q/A,	
The importance of formulating a research problem, Sources of research problems, Considerations in selecting a research problem.	Formulating a Research Problem, Sources of research problems.	Lecture, Q/A,	
Steps in formulating a research problem. How to formulate research objectives. The importance of establishing operational definitions.	Formulating a Research Problem, Steps in formulating a research problem, Establishing operational definitions.	Lecture, Q/A,	
The definition of a hypothesis. The functions of a hypothesis in your research. Different types of hypotheses and their applications.	Constructing Hypotheses, The formulation of hypothesis, Types of hypothesis.	Lecture, Q/A,	

How hypotheses are tested. How errors in the testing of a hypothesis can occur. The use of hypotheses in qualitative research	Constructing Hypotheses, Testing and Characteristics of hypothesis, Errors in testing a hypothesis.	Lecture, Q/A,	
What research design means. The important functions of research design. Issues to consider when designing your own research.	The Research Design, Function of research design, Theory of causality and the research design.	Lecture, Q/A,	
The differences between quantitative and qualitative study designs, Common study designs in quantitative research and when to use them.	Study designs based on the nature of the investigation, Philosophy guided design, Study designs in quantitative research	Lecture, Q/A,	
Different types of sampling. The calculation of sample size. The concept of saturation point	Selecting a Sample, Calculation of sample size, Types of sampling with their steps.	Lecture, Q/A,	
Collecting data using primary sources, Collecting data using primary sources, Methods of data collection in qualitative research.	Selecting a method of data collection, The Questionnaire, Prerequisites of data collection.	Lecture, Q/A,	
The purpose of a research proposal in quantitative and qualitative research. How to structure a research proposal. How to write a research proposal.	Write a Research Proposal, Characteristics of a good research report.	Lecture, Q/A,	

Reference Book:

1. Research Methodology: A Step-by-Step Guide for Beginners by Ranjit Kumar.

CSE 517 ADVANCED MACHINE LEARNING

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale:

This introductory course gives an overview of many concepts, techniques, and algorithms in machine learning, beginning with topics such as classification, linear regression etc. and ending up with more recent topics such as support vector machines, hidden Markov models etc. The course will give the student the basic ideas and intuition behind modern machine

learning methods as well as a bit more formal understanding of how, why, and when they work.

Objectives:

- To develop a deeper understanding of several major topics in machine learning;
- To develop the basic skills necessary to pursue research in machine learning.
- To decide which machine learning methods/algorithms are suitable for which type of learning problems, i.e. know about their most important weaknesses and advantages.
- To decide how to represent data to facilitate learning.

Intended Learning outcomes (ILOs)	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Understand Machine Learning, Supervised and Unsupervised Learning, Regression and Classification problem, Recommender System etc.	Machine Learning Regression Recommender System	Lecture, Discussion	Q/A, feedback
Get idea about Anomaly Detection and Dimensionality Reduction: Feature Extraction & Selection	Anomaly Detection Dimensionality Reduction	Lecture, Q/A, MMP	Analysis Algorithms
Learn from unclassified data: Clustering. Hierarchical Clustering, k-means partition clustering and N-gram	Clustering N-gram	Lecture, Q/A, MMP	Analysis Algorithms
Representing concepts as decision trees. Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Understand Hidden Markov Model	Decision Tree Hidden Markov Model	Lecture, Q/A, feedback	Analysis Algorithms
Finding Clique Graph Get knowledge about Support Vector Machine (SVM)	Clique Graph Support Vector Machine (SVM)	Lecture, Q/A, feedback, MMP	Assignment, Viva
To develop an understanding of the fundamental concepts of	Genetic Algorithm Data Mining	Lecture, Q/A, feedback	Analysis Algorithms

genetic algorithms and an ability to analyze and design genetic algorithms for optimization problems Understand the concept of Data Mining.			
Get idea about Neurons and biological motivation, Linear threshold units, Multilayer networks, Hidden layers, Overfitting and Information Retrieval	Artificial Neural Network Information Retrieval	Lecture, Q/A, feedback	Assignment, Sudden test

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Foundations of Machine Learning, Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar

2. "Fundamentals of Machine Learning for Predictive Data Analytics – Algorithms, Worked Examples, and Case Studies" by John D Kelleher and Brian Mac Namee

CSE 519 ADVANCED SOFTWARE ENGINEERING

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: This course covers the software development process, from requirements elicitation and analysis, through specification and design, to implementation, integration, testing, and maintenance (evolution). A variety of concepts, principles, techniques, and tools are presented, encompassing topics such as software processes, project management, people management, software requirements, system models, architectural and detailed design, user interface design, programming practices, verification and validation, software evolution, design pattern and software metrics. Although the emphasis will be on modern approaches some more traditional software engineering techniques will also be discussed.

Objectives:

1. Develop an understanding of project management, software process models and the ability to select the suitable model to use in software development.
2. Develop an understanding of requirements engineering process and distinguish between different types of requirements.
3. Ability to analyze, design and develop the system models for software development.
4. Ability to prepare the software requirements specification document for a software project.
5. Ability to prepare the software design pattern, software metrics and software process.
6. Demonstrate the ability to research a particular topic and develop it for a specific audience and purpose.
7. Develop and empower the presentation skills.
8. Develop the teamwork management skills.

Intended Learning Outcomes(ILOs)	Course Content	Teaching/ Learning Strategy	Assessment Strategy

Get general information of software engineering, understands socio-technical systems, critical systems, software process and project management.	Overview	Lecture, Discussion	Q/A, feedback
Able to understand the basics requirements of software engineering and know about the models and techniques that are used in the requirements engineering process.	Requirements	Lecture, Q/A, MMP	Sudden test
Gets information about abstract structures of software and specific software design issues.	Design	Lecture, Q/A, MMP	Quiz
Know the techniques for rapid software development, understand reuse-based software engineering, critical system and software evolution	Development	Lecture, Q/A, feedback	Viva
Introduced with approaches of verification, Program testing, specialized topic of critical system validation	Verification and Validation	Lecture, Q/A, feedback, MMP	Q/A, feedback
Understand people management, software cost estimation, issues of quality management, configuration management	Managing People	Lecture, Q/A, feedback	Quiz
Gets information about security engineering, service-oriented software engineering and aspect-oriented software engineering	Emerging technologies	Lecture, Q/A, feedback	Sudden test
Understand software design pattern, software metrics and software process	Planning, Design and Development	Lecture, Q/A, feedback	Feedback

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Software Engineering. By Sommerville
2. Foundations of Software Engineering by Ashfaque Ahmed, Bhanu Prasad

Recommended text books:

1. Software Engineering: Principles and Practice, 3rd edition by Hans van Vliet
2. Beginning Software Engineering by Rod Stephens

MAT 511 ADVANCED PROBABILITY, STOCHASTIC PROCESS AND OPTIMIZATION

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: The purpose of this course is to equip students with theoretical knowledge and practical skills of probability theory, stochastic process and optimization that is the fundamental basis for many other areas in mathematical sciences including statistics, modern

optimization methods and risk modeling and ability of finding the most appropriate process for modeling in particular situations arising in engineering and other fields.

Objectives:
Upon completion of the course, students will have:

1. Know the most widely used probability distributions and recognize them in applications.2 utuations arising in engineering and other fields.
2. Feasibility study for solving an optimization problem
3. Becoming a mathematical translation of the verbal formulation of an optimization problem.
4. To design algorithms, the repetitive use of which will lead reliably to finding an approximate solution
5. Evaluate and measure the performance of an algorithm.
6. Discovery, study and solve optimization problems.
7. Understand optimization techniques using algorithms.
8. Investigate, study, develop, organize and promote innovative solutions for various applications.nderstanding the most important types of stochastic processes (Queuing Process, Markov and others) and ability of finding the most appropriate process for modeling in particular si

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
● Probability ● Students will be able to: ● Define the following terms Probability, probability distribution, expectation and moments, measurability. Functions of random variables, mathematical expectations, transforms and generating functions, modes of convergence of sequences of random variables.	Probability as a set function, Borel field and extension of probability measure, probability measure notion of random variables, probability space, distribution functions, expectation and moments. Convergence of random variables, characteristic functions with properties, probability generating functions with properties, condition, martingales. **Set functions**: the concept of measurability, Simple Functions, Elementary properties of Measures, Out measure, Measurable sets and lebesque Measures, Non-Lebesque Measurable sets, Measurable	Lecture, Q/A, Multimedia Slides, White Board	

	Space, Measurable Functions, Combinations of measurable Functions, Sequences of Measurable Functions, Point wise Convergence, Convergence in Measure. **Integration**: Lebesque integral of simple functions, Integrable functions, Sequence of integrable function, The General and Reimann-Stieltjes Integral.		
Stochastic process ● Define stochastic process ● Learn the most important types of stochastic processes. ● Understand and apply Queuing Process and markov chain.	● Definition Of stochastic process, scope, application, state space, parameter space, types based on the nature of parameter space and state space, preliminary concept of transition probability distribution function, time homogeneity, independent increment, stationary independent increment, classification of general stochastic process with definitions. Markov chain: Preliminaries of transition probability: transition probability,	Lecture, Q/A, Multimedia Slides, White Board	

	transition probability matrix with real life examples, Chapman-Kolmogorov equation, n-step tpm from 1-step tpm. **Queuing Process:** Preliminaries: Congestion, queuing, queuing process with real life examples, common measurable quantities in queuing process, characteristics of queuing process, notational representation, generalized queuing model, M/M/I queuing model: the queue M/M/I, steady state solution for M/M/I model, average number of customers in the system, average number of customers waiting in the queue average amount of time that a customer spends in the system, average amount of time that a customer spends for waiting in the queue, proportion of time the server is		

	idle, proportion of time the server is busy, probability of being at least K customers in the system.		
Optimization ● Define objective function, constraint, standard form of a linear programming problem, feasible solution. ● mathematical translation of the verbal formulation of an optimization problem ● Learn and apply transportation problem, Vogel's approximation method, Fibonacci method and quadratic interpolation method.	Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems, Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – simplex method – simplex algorithm. **Transpiration problem**: initial basic feasible solution by north – west corner rule least cost method and &Vogel's approximation method – testing for optimality of balanced transportation problems. One – dimensional minimization methods classification Fibonacci method and quadratic interpolation method. Dynamic	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

	programming: dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming.		

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Introductory Operations Research, H.S Kasene and K.D Kumar.
2. Cooper. R.B: Introduction to Queuing Theory, Norh Holand, Elsevier.

References:

1. G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, 3rd Edition, Oxford University Press,2001.
2. S.M. Ross, Stochastic Processes, 2nd Edition, Wiley, 1996(WSE Edition).
3. J. Medhi, Stochastic Processes, 3rd Edition, New Age International, 2009.
4. H.M. Taylor and S. Karlin, An Introduction to Stochastic Modeling, 3rd Edition, Academic Press, New York, 199
5. **Mathematical Statistics with Applications**, by Wackerly, Mendenhall and Schaeffer, Duxbury, 2008.

CSE 521 DATA WAREHOUSING AND DATA MINING

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale:

This course discusses techniques for preprocessing data before mining and presents the concepts related to data warehousing, online analytical processing (OLAP), and data generalization. It presents methods for mining frequent patterns, associations, and correlations. It also presents methods for data classification and prediction, data-clustering approaches, and outlier analysis.

Objectives:

Students who successfully complete this course should be able to

1. Interpret the contribution of data warehousing and data mining to the decision-support level of organizations
2. Evaluate different models used for OLAP and data preprocessing
3. Categorize and carefully differentiate between situations for applying different data-mining techniques: frequent pattern mining, association, correlation, classification, prediction, and cluster and outlier analysis
4. Design and implement systems for data mining
5. Evaluate the performance of different data-mining algorithms
6. Propose data-mining solutions for different applications

Learning outcomes	Course Content	Teaching – Learning Strategy	Assessment Strategy
Overview of Data Mining	Background on data objects and statistical concepts. Types of data to be mined. General classification of data-mining tasks.	Lecture, Slides, Q/A,	Assignment
Data Preprocessing	Introduction to techniques for preprocessing data before mining. Discussion on concepts such as the cleaning, integration, reduction, transformation, and discretization of data.	Lecture, Q/A	Assignment.
Overview of Data Warehousing and OLAP	Introduction to data warehousing, OLAP, and data generalization.	Lecture, Q/A,	Assignment
Data Cube Computation and Multidimensional Data Analysis	A detailed study of methods for data cube computation, advanced query processing. Multidimensional data analysis.	Lecture, Q/A,	Example Problem solving
Mining Frequent Patterns, Associations, and Correlation	Methods for mining frequent patterns, associations, and correlations.	Lecture, Q/A	Example problem solving
Classification	Ways of classifying data: decision tree induction, Bayesian classification. Rule-based classification. Neural networks, support vector machines, associative	Lecture, Q/A	Example problem solving

	classification, *k*-nearest-neighbor classifier. Case-based reasoning. Genetic algorithms, rough sets, and fuzzy set approaches.		
Cluster Analysis	Major approaches to the detection of anomalies, such as the statistical, proximity-based, clustering-based, and classification-based methods.	Lecture, Q/A	Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

Jiawei Han, Micheline Kamber, and Jian Pei.
Data Mining: Concepts and Techniques (3rd ed.). Morgan Kaufmann, 2012.

Recommended text books:

1. Ian H. Witten, Eibe Frank, and Mark A. Hall.

Data Mining: Practical Machine Learning Tools and Techniques (3rd ed.). Morgan Kaufmann, 2011.

CSE 523 PATTERN RECOGNITION

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Objectives:

1. Understand basic concepts in pattern recognition
2. Gain knowledge about state-of-the-art algorithms used in pattern recognition research
3. Understand pattern recognition theories, such as Bayes classifier, linear discriminant analysis.
4. Apply pattern recognition techniques in practical problems.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
The first module concerns fundamental concepts Pattern Recognition	1 Overview, Classifier Evaluation, Bayes' Decision Theory	Lecture, Q/A, Multimedia Projector	Assignment,
Learn about Neuron Model and Network Architectures	Basic structures of a neural network, Feed Forward Network, Recurrent Network, classification problems and Illustrative	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving

	examples. EM algorithms, HMM		
Learn about Perceptron learning rules.	**Perceptron Architecture, Perceptron Learning rules, Training Multi-layer perceptron.**	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Clustering, Classification and Back propagation Networks	**K-means clustering, ADALINE network,** steepest descent method and learn to derive the equations. Learn the back propagation algorithm with the example. Support vector Machine	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Classifier	Classifier Combination and feature selection	Lecture, Q/A, Multimedia Projector, Workshop	Assignment,
Structural and Synthetic Pattern Recognition	Stochastic Learning, Structural and Synthetic Pattern Recognition, Algorithm Independent Learning	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Presentations	Projects and research paper presentation.	Multimedia Projector,	Problem Solving Assessment

RECOMMENDED BOOKS AND REFERENCES

Text books:

- ✔ Duda, Hart and Stork, *Pattern Classification*, Second Edition, Wiley, 2001.

Useful supplementary books:

- ✔ T.M. Mitchell, *Machine learning*, McGraw-Hill, New York, 1997.
- ✔ S. Theodoridis, K. Koutroumbas, *Pattern recognition*, Academic Press, 1999.

CSE 553 WIRELESS NETWORKS

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: Wireless communications is one of the most active areas of technology development of our time. This development is being driven primarily by the transformation of what has been largely a medium for supporting voice telephony into a medium for supporting other services, such as the transmission of video, images, text, and data. Thus, similar to the developments in wireline capacity in the 1990s, the demand for new wireless capacity is growing at a very rapid pace. This course is designed to help the students to learn more sophisticated wireless communication techniques than the ones in the undergraduate course. Many of the technique relate to some type of optimization, and arise in many important applications, which they will typically encounter in other graduate courses, their research, and in the real-world. While the applications are important, the techniques used to solve them are well beyond the scope of an undergraduate course.

Objectives:
By the end of the semester, students should develop the following skills:

1. Understand and learn about current wireless network system as well as their pitfalls.
2. Understand the cellular system design and able to design a better one depending on the demand.
3. Given a practical application, identify the computational issues and apply suitable design to solve it effectively.
4. Able to apply digital modulation technique and enhance the performance by applying multi carrier modulation.

Learning outcomes	Course Content	Teaching – Learning Strategy	Assessment Strategy
Introduction: ● Give explanation about wireless system and the spectrum system. ● Give knowledge about wireless technical issues.	History of wireless communication, Wireless vision, Technical issues, Current wireless system, wireless spectrum, Standards.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Path Loss & Shadowing: ● Explain the behavior of radio waves as they travel, or are propagated, from one point to another, or into various parts of the atmosphere. ● Give applications of empirical path loss and shadow fading.	Radio wave propagation, Transmit and receive signal models, Free space path loss model, Ray tracing and empirical path loss models, Simplified path loss model, Shadow fading, Combined path loss and shadowing, Outage	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

	probability, Cell coverage area.		
Radio Paging: ● Illustrate the application of paging types. ● Explain wide area paging and all types of transmission specifications.	Introduction, Paging Receiver Types, On site paging, Transmitter specifications, Wide area paging, Transmission specifications, Paging Receivers Architecture.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Cellular System Design: ● This section will help students to learn how cellular network works and how to design a cellular network. ● Explain about handoff techniques, the importance and application of trucking. ● Give idea about capacity and coverage improvements.	Introduction, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trucking & GoS capacity and coverage improvement.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Statistical Multipath Channel: ● In this chapter we examine fading models for the constructive and destructive addition of different multipath components introduced by the channel. Although these multipath effects are captured in the ray-tracing models for deterministic channels, in practice deterministic channel models are rarely available and so we must characterize multipath channels statistically. In this chapter we model the multipath channel by a random time-varying impulse response. We will develop a statistical characterization of this channel model and describe its important properties.	Time varying Channel impulse response, Narrow band fading model, wideband fading models, Discrete time model, Space-time channel model.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Digital Modulation Performance: ● This Chapter will give a details idea about every kinds of digital modulations. ● Explain about their performance unit and illustrate which one is better than which one	SNR and bit/symbol energy, Error Probability in AWGN channel for BPSK,QPSK,MPSK,MQAM,FSK,CPFSK and differential modulation;	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

● Also give idea about the average probability of error and managing technique of handing error.	Alternate Q-function; Performance in fading channel, Average Probability of error, Combined Outage 0and average error probability, Doppler spread, ISI.		
Diversity & Equalization: ● Give brief knowledge about receiver diversity. ● Enlighten with practical knowledge of Threshold combining. ● Solve problem but equalizer noise enhancement.	Receiver diversity system model, Selection combining, Threshold combining, MRC, EGC, Transmit diversity, Alamouti Scheme. Diversity analysis, Equalizer noise enhancement; Equalizer types; ISI free Transmission; ZF and MMSE Equalizer ; MLSE, Decision feedback equalizer; Training and tracking for Adaptive equalizer.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Spread Spectrum: ● Going through all the SS principle, explore their model and have a practical knowledge of these principles.	SS principle, DSSS system model, Spreading codes, system model, synchronization, RSKE receiver, FHSS, Spreading code for Multi-user DSSS, DL & UL channel, Multi-user detection, MC-CDMA, Multiuse FHSS.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Multi carrier modulation: ● Learn CDMA technique ● Solve real life problem using these technique. ● Define terms cyclic prefix, OFDM ● Give efficient way to solve difficult problems using multi carrier	Data transmission using multi carrier, MCM with overlapping sub channel, Sub carrier fading mitigation, Cyclic prefix, OFDM, Matrix reorientation of OFDM, MIMO-	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

modulations.	OFDM, MC-CDMA.		

RECOMMENDED BOOKS AND REFERENCES

Reference Book:

3. Theodore S. Rappaport, Wireless Communication: Principle and Practice, 2nd Edition, 2002; prentice Hall.
4. David Tse and Pramod Viswanath Fundamentals of wireless communication, 2005; Cambridge University press.
5. Andreas F. Molisch, Wireless Communications, 2nd Edition, 2010 Wiley.
6. Andrea Goldsmith, wireless communications, 2005; Cambridge University Press.

CSE 555 COMPUTER SECURITY & CRYPTOGRAPHY

Credit Hours: 3, Contact Hours: 3 per week **Marks: 100**

Objectives:

This course covers fundamental issues and first principles of security and information assurance. The course will look at the security policies, models and mechanisms related to confidentiality, integrity, authentication, identification, and availability issues related to information and information systems. Other topics covered include basics of cryptography (e.g., digital signatures) and network security (e.g., intrusion detection and prevention), risk management, security assurance and secure design principles, as well as e-commerce security. Issues such as organizational security policy, legal and ethical issues in security, standards and methodologies for security evaluation and certification will also be covered.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Security Basics	General overview and definitions, Security models and policy issues	Lecture, Q/A, Multimedia Projector	Assignment,
Basic Cryptography and Network security	Introduction to cryptography and classical cryptosystem, Authentication protocols and Key Management, IPSec, VPNs, E-commerce issues	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving

Basic Cryptography and Network security	Data Encryption Standard (DES), DES (Contd.), Triple DES, Modes of Operation, Stream Cipher, Pseudorandom Sequence.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving
Basic Cryptography and Network security	Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Symmetric Key cryptography, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Authentication issues	Message Authentication, Digital Signature, Key Management, Hash Function	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Systems Design Issues and Information assurance	Design principles, Security Mechanisms, Auditing Systems, Risk analysis, System verification and evaluation.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Intrusion Detection and Response	Attack Classification and Vulnerability Analysis, Detection, Containment and Response/Recovery	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Legal, Ethical Issues	Malicious code, Mobile code, Digital Rights Management, Forensics, Emerging issues: E/M-commerce security, Multi-domain Security Issues etc.	Lecture, Q/A, Multimedia Projector, Workshop	Assignment

Recommended Books:
Text books:
Computer Security: Art and Science by Matt Bishop
Recommended text books:

- Security in Computing, 2nd Edition, Charles P. Pfleeger, Prentice Hall
- Security Engineering: A Guide to Building Dependable Distributed Systems, Ross Anderson, Wiley, John & Sons, Incorporated, 2001
  Building Secure Software: How to avoid the Security Problems the Right Way, John Viega, Gary McGraw, Addison-Wesley, 2002

CSE 557 CLOUD COMPUTING

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Objectives:

This course provides a hands-on comprehensive study of Cloud concepts and capabilities across the various Cloud service models including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and Business Process as a Service (BPaaS). IaaS topics start with a detailed study the evolution of infrastructure migration approaches from VMWare/Xen/KVM virtualization, to adaptive virtualization, and Cloud Computing / on-demand resources provisioning. Mainstream Cloud infrastructure services and related vendor solutions are also covered in detail. PaaS topics cover a broad range of Cloud vendor platforms including AWS, Google App Engine, Microsoft Azure, Eucalyptus, OpenStack and others as well as a detailed study of related platform services such as storage services that leverage Google Storage, Amazon S3, Amazon Dynamo, or other services meant to provide Cloud resources management and monitoring capabilities. The SaaS and PaaS topics covered in the course will familiarize students with the use of vendor-maintained applications and processes available on the Cloud on a metered on-demand basis in multi-tenant environments. The course also covers the Cloud security model and associated challenges and delves into the implementation and support of High Performance Computing and Big Data support capabilities on the Cloud. Through hands-on assignments and projects, students will learn how to configure and program IaaS services. They will also learn how to develop Cloud-based software applications on top of various Cloud platforms, how to integrate application-level services built on heterogeneous Cloud platforms, and how to leverage SaaS and BPaaS solutions to build comprehensive end-to-end business solutions on the Cloud.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Cloud Computing Overview	Cloud Computing definition and characteristics, Cloud Computing and SOA,	Lecture, Q/A, Multimedia Projector	Assignment,

	Enterprise Cloud drivers and adoption trends, Cloud service models/types		
Infrastructure as a Service (IaaS)	Evolution of infrastructure migration approaches, Cloud Infrastructure services, IaaS mainstream offerings	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving
Platform as a Service (PaaS)	Evolution of computing paradigms and related components, Cloud platform services, PaaS vendor solutions	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Software as a Service (SaaS)	Overview of the Cloud application development lifecycle, SaaS platform services, business intelligence	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Business Process as a Service (BPaaS)	Overview of BPM on the Cloud (i.e., BPaaS vs. managed business services and BPO) and BpaaS sample solutions, BPaaS platform services, BPaaS vendor solutions	Lecture, Q/A, Multimedia Projector, Workshop	Assignment,
Managing cloud storage	Controlling unstructured data in the cloud, Deploying relational databases in the cloud, Improving data availability.	Lecture, Q/A, Multimedia Projector, Workshop	Assignment
Virtualization	Types of cloud virtualization, Befits of virtualization	Lecture, Q/A, Multimedia Projector	Assignment
Cloud Security	Cloud security challenges, Cloud security approaches: encryption, tokenization/obfuscation , cloud security alliance standards, cloud security models and related patterns, Cloud security in mainstream vendor solutions	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Enterprise Cloud-Based	Overview of High	Lecture, Q/A,	Problem

High Performance Computing (HPC) Applications	Performance Computing (HPC) on Cloud, Enterprises HPC applications (high-performance grid computing, high-performance big data computing/analytics, high performance reasoning)	Multimedia Projector, Workshop	solving, Assignment

Recommended Books:
Text books:
Cloud Computing: from beginning to end by Ray J. Rafaels
Recommended text books:

1. Cloud Computing: A Hands-On Approach By Arshdeep Bagha and Vijay Madisetti
2. Cloud Economics: The business value of Cloud Computing By Joe Weinman
3. Cloud Computing Design Patterns by Thomas Erl and Others.

CSE 559 NATURAL LANGUAGE PROCESSING

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale:

The goal of this new field is to get computers to perform useful tasks involving human language, tasks like enabling human-machine communication, improving human-human communication, or simply doing useful processing of text or speech. This course introduces the fundamental concepts and techniques of natural language processing (NLP). Students will gain an in-depth understanding of the computational properties of natural languages and the commonly used algorithms for processing linguistic information. The course examines NLP models and algorithms using both the traditional symbolic and the more recent statistical approaches.

Objectives:

- How key concepts from NLP are used to describe and analyze language
- POS tagging and context free grammar natural language processing
- Understanding semantics and pragmatics of language for processing
- Writing programs in Python to carry out natural language processing

Intended Learning outcomes (ILOs)	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Get introduced with NLP, Get idea about Words, Speech, Syntax, Semantics & Pragmatics and Applications exploiting each	Introduction and Regular Expressions and Automata: Words, Speech, Syntax, Semantics & Pragmatics and Applications exploiting each	Lecture, Discussion	Q/A, feedback
Understand morphology and FSTs, finite-state transducers, many bugs, words and sub words, sentence tokenization, including algorithms for English as well as the max match algorithm for Chinese word segmentation, spelling correction and minimum edit distance.	Words and Transducers: Morphology, Finite-state transducers, Sentence tokenization, Spelling correction and minimum edit distance.	Lecture, Q/A, MMP	Analysis Algorithms
Understand bigram and trigram, HMM part-of-speech tagging, including Viterbi decoding and deleted interpolation smoothing.	N-grams, Part-of-Speech Tagging	Lecture, Q/A, MMP	Analysis Algorithms
Introduced with two sequence models: HMMs and MEMMs. It gives the details of Hidden Markov Models, including Forward, Viterbi, and EM. Understand CFGs for English, treebanks with a focus on the Penn Treebank, dependency grammars, Categorical grammar, and grammars for spoken language processing	Hidden Markov and Maximum Entropy Models Formal Grammars of English	Lecture, Q/A, feedback	Analysis Algorithms
Learn parsing with CFGs,	Syntactic Parsing	Lecture, Q/A,	Assignment,

CKY and agenda-based (chart) parsing, base-phrase chunking and the use of IOB tags. In statistical parsing the ILOs are PCFGs, probabilistic CKY parsing, parent annotations, the Collins parser	Statistical Parsing	feedback, MMP	Viva
Understand Feature Structures, Feature Structures in the grammar, Implementing Unification Unrestricted Grammars, Context-Sensitive Grammars, Context-Sensitive Grammars etc.	Features and Unification Language and Complexity	Lecture, Q/A, feedback	Analysis Algorithms

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition
   Second Edition
   Daniel Jurafsky and James H. Martin
2. Handbook of Natural Language Processing and Machine Translation
   Joseph Olive · Caitlin Christianson · John McCary

CSE 559 NEURAL NETWORKS & FUZZY SYSTEMS

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Objectives:

(1) The principal objective of this subject is to introduce students to neural networks and fuzzy theory from an engineering perspective

(2) Develop the skills to gain a basic understanding of neural network theory and fuzzy logic theory.

(3) Explore the functional components of neural network classifiers or controllers, and the functional components of fuzzy logic classifiers or controllers.

(4) Develop and implement a basic trainable neural network or a fuzzy logic system for a typical control, computing application or biomedical application.

(5) As trainable dynamic systems, these intelligent control systems can learn from experience with numerical and linguistic sample data.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
The first module concerns fundamental concepts of artificial neural systems and fuzzy logic theory.	Objectives, History, Biological Inspiration Applications, Further	Lecture, Q/A, Multimedia Projector	Assignment,

	reading (some ideas about research possibilities).		
Learn about computing	Soft computing, Evolutionary Computing	Lecture, Q/A, Multimedia Projector	Assignment
Learn about neuron structure with their abbreviated notation	Single input single output neuron, multiple input single output neuron, multiple input multiple output neuron, implement these structure in different functions i.e. positive linear, log -sigmoid	Lecture, Q/A, Multimedia Projector	Problem solving
Learn about Neuron Model and Network Architectures	Basic structures of a neural network, Feed Forward Network, Recurrent Network, Hamming Network, Hopfield Network, Prototype patterns, Delay block classification problems and Illustrative examples.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving
Learn about decision boundary, nervous system	Decision boundary, Peripheral nervous system, Central nervous system, use of Bias	Lecture, Q/A, Multimedia Projector	Assignment
Learn about Perceptron learning rules.	**Perceptron Architecture, Perceptron Learning rules, Training Multi-layer perceptron.**	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving Assignment
Clustering, Classification and Back propagation Networks	**K-means clustering, ADALINE network,** steepest descent method and learn to derive the equations. Learn the back propagation algorithm with the example.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment
Fuzzy Set Theory, Fuzzy Systems	Introduce with Fuzzy sets, membership functions, set	Lecture, Q/A, Multimedia Projector,	Assignment,

	operation concepts, Fuzzy relation concepts. Learn Fuzzy logic, Fuzzy quantifiers, Fuzzy Inference, Fuzzy tautology, Fuzzy Rule Base systems, defuzzification, application of fuzzy controllers.	Workshop	
Learn consistent logical argument constructor	Modus ponens, Modus Tollens, Chain Rule	Lecture, Q/A, Multimedia Projector	Problem solving
Genetic Modeling	Three concepts - Reproduction, Cross-over and Mutation. For reproduction, read the roulette selection method.	Lecture, Q/A, Multimedia Projector, Workshop	Problem solving, Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Neural Network, Fuzzy Logic and Genetic Algorithms by S. Rajesekaran, G. A. Vijayalakshmi
2. Neural Network Design by M. Hagan, H. Demuth, M. Beale,

Recommended text books:

1. Fuzzy logic with Engineering Applications, McGraw Hill, New york, 1996
   By Timothy J.Ross

2. Introduction to Neural Networks, Fuzzy Logic & Genetic algorithms
   By Sudarshan K. Valluru, T. NageswaraRao

CSE 561 ADVANCED ALGORITHM & COMPLEXITY ANALYSIS

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: Learn to analyze iterative and recursive algorithms for use of resources (time, memory, parallelism, bandwidth, randomness, etc.). Develop fluency with big-O notation, and learn to choose and implement efficient algorithms for numeric, combinatorial, and geometric problems. Learn basic concepts and terminology in computability and computational complexity.

Objectives:

1. Exposure to more sophisticated analysis techniques, e.g. amortized complexity.
2. Exposure to specialized data structures and algorithms.

3. Exposure to models of algorithm design

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Students should be able to: ● Understand the importance of algorithm analysis. ● Understand different mathematical terms.	Introduction to the Course **Models:** Preliminaries, mathematical background, algorithms analysis.	Lecture, Q/A, PowerPoint Slides	
Students should be able to: ● Learn recursive procedures ● Understand recursion trees	**Recursion and Induction**: Recursive procedures, proofs by Induction, recursion trees.	Lecture, Q/A,	
Students should be able to: ● Learn different types of sorting ● Compare between different sorting algorithms.	**Sorting**: Insertion search, selection sort, Quicksort, merge sort, heapsort, low bound of comparison of keys, comparison of sorting algorithms, shell sort, Radix sort.	Lecture, Q/A,	Assignment
Students should be able to: ● Understand different trees ● Learn hashing and text compression.	**Data structures and algorithms for sets**: Balanced binary trees, 2-3 trees, B-trees, structures for sets, Hashing, text compression (Huffman coding).	Lecture, Q/A,	Assignment
Students should be able to: ● Understand graphs algorithm and can implements them. ● Learn spanning trees, matching and network flow	**Graphs algorithms:** Definition and implementations, Searching, connected components, Topological sort, path problems, spanning trees, Network Flow, Matching.	Lecture, Q/A,	Assignment
Students should be able to: ● Learn greedy algorithms, divide and conquer. ● Implement dynamic	**Algorithm Design techniques**: Greedy algorithms, divide and conquer, dynamic programming, randomized algorithm.	Lecture, Q/A,	Assignment

programming and randomized algorithm.			
Students should be able to: ● Understand cryptographic computations, Fast Fourier transform information security algorithms and protocols.	**Numeric algorithms:** Fundamental algorithms involving numbers, cryptographic computations, Fast Fourier transform information security algorithms and protocols.	Lecture, Q/A,	
Students should be able to: ● Learn Automata, string matching (Boyer and Moore algorithm ● Learn Knuth-Morris-Pratt algorithm), Pattern Matching.	**String algorithms**: Automata, string matching (Boyer and Moore algorithm, Knuth-Morris-Pratt algorithm), Pattern Matching.	Lecture, Q/A,	Assignment
Students should be able to: ● Understand Complexity classes P and NP, NP-completeness, some NP-complete problems.	**Introduction to complexity Theory**: Complexity classes P and NP, NP-completeness, some NP-complete problems.	Lecture, Q/A,	
Students should be able to: ● Learn Parallel Design Strategies ● Understand Distributed Computation Algorithms.	**Parallel Algorithms and Distributed Algorithms:** Parallel Design Strategies, Distributed Computation Algorithms.	Lecture, Q/A,	Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

The Design and Analysis of Algorithms,3rd edition by Anany Levitin, Addison-Wesley, 2012.

Recommended text books:

1. Introduction to Algorithms: T.H. Cormen, C.E.Leiserson and R.L. Rivest
2. Fundamentals of Algorithmic: G. Brassard and P. Bratley
3. Approximation Algorithms: Vijay V. Vazirani
4. Randomized Algorithms: R. Motwani and P.Raghavan
5. Reference book: Algorithmic: The spirit of computing: D.Harel

CSE 565 DISTRIBUTED AND PARALLEL COMPUTING
Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: Distributed and Parallel computing systems are central to computing activities. An operating system is a program that acts as an intermediary between a user of a computer and the computer hardware. Two primary aims of operating systems are to manage resources (e.g. CPU time, memory) and to control users and software. Operating system design goals are often contradictory and vary depending of user, software, and hardware criteria. This course describes the fundamental concepts behind operating systems, and examines the ways that design goals can be achieved. The course will also cover Parallel programming, advanced topics of distributed system, Cluster and grid computing, distributed algorithms and Protocol Validation.

Objectives:
1. Understand the basics of operating system, its history and architecture
2. Learn scheduling algorithms, threads and synchronization process
3. Understand memory management and file management system
4. Analyze distributed system architecture, distributed file system.
5. Learn Parallel programming and distributed systems
6. Understand Cluster and grid computing, distributed algorithms and Protocol Validation

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
Introduction to Distributed System	Goal of a Distributed System, Connecting Users and resources, Transparency in a DS, Openness and Scalability, System Models	Lecture, Q/A, feedback	Q/A, Quiz
Parallel Programming	Parallel vs Distributed Computing, Clustered Computing, Grid Computing, Flynn's Taxonomy, Types of Parallelism	Lecture, Q/A, feedback	Q/A, Quiz, Assignment
Hardware and Software Concept	Different types of multiprocessor and multicomputer, Distributed Operating System, Distributed Shared memory system	Lecture, Q/A, feedback	Q/A, Quiz
Middleware	Network Operating System, Middleware models, Middleware services.	Lecture, Q/A, feedback	Q/A, Quiz

Remote Procedure call	Client and server stubs, Parameter Passing, Goals of DCE RPC, Writing a client and a server, Binding a client to server, Remote object invocation,	Lecture, Q/A, feedback	Q/A, Quiz
Message oriented communication	Persistence and Synchronicity of a communication, Message queuing model	Lecture, Q/A, feedback	Q/A, Quiz
Parallel Algorithms	Decomposition, Tasks and Dependency Graph, Degree of Concurrency, Processes and Mapping, Decomposition Techniques, Characteristics of Task, Mapping Techniques, Parallel Algorithm Models.	Lecture, Q/A, feedback	Q/A, Quiz
Processes and Threads	Process Management, Single and multithreaded processes, Combination of User threads and LWPs, Organization of servers, Code migration	Lecture, Q/A, feedback	Q/A, Quiz

Recommended Books and References

Text Books:

1. Distributed and Parallel Computing by Hesham El Rewini, Ted G. Lewis, T. G. Lewis
2. Topics in Parallel and Distributed Computing By Sushil K. Prasad, Anshul Gupta, Arnold L. Rosenber, Alan Sussman, Charles Weems.

CSE 567 OPTICAL WIRELESS COMMUNICATION

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: This course is designed to help the students to learn Optical Wireless Communication more sophisticatedly than the ones in the undergraduate course. The developing field of optical wireless communication (OWC) system is viewed as potential reciprocal innovation to the radio recurrence remote interchanges in specific applications. It is regarded as a conceivable innovation later on fifth Generation correspondence systems to address the range blockage and improve the framework's ability. The applications of

knowledge in Optical Wireless Communication are important and contain future scope, so, improvement in this field via this course will be preference.

Objectives:
By the end of the semester, students should develop the following skills:

1. understand and apply the knowledge about transmission distances, low power loss of optical fiber, greater bandwidth privileges etc. discussed in class, prove their efficiency,
2. understand the basic idea behind much lower attenuation and interference, demand in complicated applications so that they are able to develop knowledge required to solve new problems where these technique can be applied, and
3. Given a practical knowledge, identify the future research scope and apply to future development.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Students will be able to: ● Understand what is Optical Wireless Communication and brief about its emergence and current OWC Challenges . ● Analyze the radio comparison complexity and determine the application areas. ● Explain the use of modulation techniques and modulation schemes ● Explain the use of OWC Links with Diversity Techniques, Transmitter–Receiver Diversity in a Log-Normal Atmospheric Channel, understanding of Visible Light Communications system	● Introduction Optical Wireless Communication Systems: Wireless Access Schemes, A Brief History of OWC, OWC/Radio Comparison, Link Configuration, OWC Application Areas, Safety and Regulations, Maximum Permissible Exposures, OWC Challenges ● Optical Sources and Detectors: Light Sources, Light-Emitting Diode, LED Structure, Planar and Dome LED, Edge-Emitting LED, LED Efficiencies, Internal Quantum Efficiency, External Quantum Efficiency, Power Efficiency, Luminous Efficiency, LED Modulation Bandwidth ● Channel Modeling: Indoor Optical Wireless Communication Channel, Artificial Light Interference, Outdoor Channel ● Modulation Techniques: Analogue Intensity Modulation, Digital Baseband Modulation Techniques, Pulse Position Modulation, Pulse Interval Modulation, Comparisons of Baseband Modulation Schemes ● System Performance Analysis Indoor: Effect of Ambient Light Sources on Indoor OWC Link Performance, Effect of FLI without Electrical High-Pass Filtering, Effect of FLI with Electrical High-Pass Filtering, Link Performance	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

	for Multipath Propagation, Mitigation Techniques, Equalization as a Classification Problem ● FSO Link Performance under the Effect of Atmospheric Turbulence: ON–OFF Keying, Pulse Position Modulation, Subcarrier Intensity Modulation, Atmospheric Turbulence-Induced Penalty ● Outdoor OWC Links with Diversity Techniques: Atmospheric Turbulence Mitigation Techniques, Receiver Diversity in Log-Normal Atmospheric Channels, Transmitter Diversity in a Log-Normal Atmospheric Channel, Transmitter–Receiver Diversity in a Log-Normal Atmospheric Channel, Terrestrial Free Space Optical Links with Subcarrier Time Diversity ● Visible Light Communications: System Description, System Implementations, Multiple-Input–Multiple-Output VLC ● MATLAB implementation		

RECOMMENDED BOOKS AND REFERENCES

Required: Optical Wireless Communications, S. Rajbhandari, W. Popoola, Z. Ghassemlooy, 2017.

Other references:

- Fiber-Optic Communication System by Govind P. Agrawal
- Franz and Jain, "Optical communication system ", Narosa Publications, New Delhi, 1995.

Reference Book:

1. Sklar; Digital Communications, Pearson.
2. Proakis; Digital Communications, TMGH.

CSE 569 SOFTWARE TESTING AND QUALITY ASSURANCE

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: This course is designed to study the developing tools and techniques for assuring software quality. It includes topics which ensure processes, procedures as well as standards suitable for correct implementation and delivery of software projects. Practical exercises give experience of design, specification, execution of tests plus test automation using tools

through a mixture of instructor-directed exercises and student research leading to knowledge sharing.

Objectives:
By the end of the semester, students should develop the following skills:

1. Understand the requirements are stated and managed for a software project.
2. Understand and identify weaknesses and problems in the processes and correcting those for continuous improvement of the project. And,
3. Understand how to maintain the quality of a software project.

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Basic concepts and preliminaries ● Know the basic concepts of software testing and quality assurance.	Software quality, Role of testing, Verification and Validation, Failure, Error, Fault, and Defect, Objectives of Testing, Test cases, White-Box and Black-Box Testing, Test Planning and Design, Monitoring and Measuring Test Execution, Test Tools and Automation.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Unit Testing	Concept of Unit Testing, Static Unit Testing, Defect Prevention, Dynamic Unit Testing, Mutation Testing, Debugging	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Control Flow Testing	Outline of Control Flow Testing, Control Flow Graph, Paths in a Control Flow Graph, Path Selection Criteria, Generating Test Input, Examples of Test Data Selection, Containing Infeasible Paths.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Data Flow Testing	General Idea, Data Flow Anomaly, Overview of Dynamic Data Flow Testing, Data Flow Graph, Data Flow Terms, Data Flow Testing Criteria, Comparison of Data	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

	Flow Test Selection Criteria, Feasible Paths and Test Selection Criteria.		
System Testing	System Test Categories, System Test Design, System Test Planning and Automation, System Test Execution.	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Software Reliability	Definitions of Software Reliability, Factors Influencing Software Reliability, Applications of Software Reliability, Reliability Models	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Software Quality	Five Views of Software Quality, Quality Models, Specification of Quality Requirements, Product Development & Delivery Issues, Software Development processes & Maturity, Software Quality Management Process, Total Quality Management, Improvement Cycle, SQA Planning & Management, Organizing the SQA effort, Software Quality Standard		

RECOMMENDED BOOKS AND REFERENCES

Reference Book:

1. Software Testing and Quality Assurance: Theory and Practice, Edited by Kshirasagar Naik and Priyadarshi Tripathy
   Copyright © 2008 John Wiley & Sons, Inc.

CSE 571 BIG DATA ANALYTICS

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: This course is designed to help the students to learn about different data sets and their implementation. With the help of different data algorithm students can examine large amount of data, discover hidden pattern and many more. Analyzing large data sets and getting the result almost immediately is also possible with modern technology of big data. With large research area Big Data is an excellent inclusion for analysis as well as business development.

Objectives:
By the end of the semester, students should develop the following skills:

- Understand different type of data sets, their scopes and representations.
- Implement different data algorithms with proper technique, maximizing efficiency and enter into the world of research with Big Data
- Ability to solve practical problem

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
● What is Big Data? ● Structured, unstructured, semi-structured Big Data ● Volume, Velocity, Variety ● Veracity ● Visibility, Value ● Variability, Viscosity, Virility, Volatility ● OLTP, OLAP, RTAP	Big data, Categories of big data, 3V, 4V, 6V, Harnessing big data, Benefits	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
Parallel algorithms ● Traditional data mining life cycle ● CRISP DM Methodology(Business understanding, data understanding, data preparation , Modeling, Evaluation, Deployment) ● SEMMA Methodology (Sample, explore, modify, model, asses) ● Big data life cycle (Business problem definition, data acquisition, data munging, data storage, exploratory data analysis, modeling, implementation ● Define Hadoop ● Hadoop architecture	● Crisp DM Methodology ● Semma Methodology ● Big Data life cycle ● Hadoop ● HDFS ● Yarn ● Map Reduce	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

● Hadoop Yarn ● How does Hadoop work ● Advantages of Hadoop ● Distributed OS, Networked OS ● Name node, Data node ● HDFS architecture ● Hadoop at Facebook ● Define Map reduce ● How does Mad Reduce work ● Map Reduce engine			
● Define Yarn ● Why Yarn ● Comparing map reduce with yarn ● with yarn Hadoop becomes a distributed OS ● Yarn architecture ● Node manager ● Application Master ● Container ● Application submission flow ● Application initiation, progress ● Resource manager recovery ● Critical path problem, reliability problem, equal split issue, single split may fail, aggregation of result ● Parallel processing, data locality, ● Mapper phase code, reducer phase code, driver code	● Yarn ● Job tracker, task tracker ● Execution sequence ● Application Initiation ● Application progress ● Map reduce	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments
● Define Zookeeper ● Zookeeper in the Hadoop ecosystem ● Fallacies of distributed computing ● Z nodes ● Z node flags ● watch flag	● Zookeeper ● Coordination ● Zookeeper principle ● Zookeeper strategy ● Zookeeper terminology ● Z nodes, watch flag	Lecture, Q/A, Multimedia Slides, White Board	Quiz and Assignments

• session • Hive, Characteristics of hive • Pig • data model • meta store • Physical layout • Hive architecture • Hive working • different types of hive • pros, cons • Define H Base • H Base vs HDFS • HBASE vs RDBMS • Features of HBASE • Where to use HBASE • Hive on HBASE	• Hive • Pig • H Base		

RECOMMENDED BOOKS AND REFERENCES

Required: Big Data Analytics, Venkat Ankam.

Other references:

- Applications of Big Data Analytics, Mohammed M. Alani , Hissam Tawfik, Mohammed Saeed, Obinna Anya
- Big Data & Building technology integration , John J. "Jack" McGowan, CEM

CSE 573 CYBERCRIME AND INTELLECTUAL PROPERTY LAW

Credit Hours: 3, Contact Hours: 3 per week **Marks: 100**

Rationale:

This course offers a comprehensive introduction to fraud and cybercrime. The course aims to provide students with an understanding of the evolving nature of fraud and cybercrime as growing crime categories. The course will introduce the students to a wide range of difference types of fraud and cybercrime, providing students with the tools to identify and analyze their prevalence, understand victimization and critically assess offender methodologies. Students will gain an understanding of the key prevention, disruption and detection approaches used by governments, law enforcement, and regulatory agencies and corporate and private sectors groups in combatting these types of crimes.

Objectives:

A candidate who has successfully completed this course should be able to:

1. Articulate the main elements of various cybercrime offences
2. Understand the unique challenges posed to law enforcement agents, policy makers and prosecutors

3. Appreciate the level of technical complexity and evolving issues in high tech crime
4. To be able to engage in debate on policy reform in the area
5. Explain and provide better instruction to a digital forensic specialist
6. Completion of an independent research essay of peer-review quality

Learning outcomes	**Course Content**	**Teaching – Learning Strategy**	**Assessment Strategy**
Introduction: The nature of cybercrime	Cyber security and cybercrime International dimensions of cybercrime Consequences for developing countries Typology of cybercrime Development of computer crime and cybercrime Extent and impact of cybercrime offences	Lecture, Slides, Q/A,	Assignment
The phenomena of cybercrime	Offences against the confidentiality, integrity and availability of computer data and systems Content-related offences Copyright and trademark related offences Computer-related offences Combination offences	Lecture, Q/A	Assignment
Challenges of fighting cybercrime	Opportunities. General challenges. Legal challenges.	Lecture, Q/A,	Assignment
Technologies behind cybercrime	Domain name system, Web-poisoning, Web hi-	Lecture, Q/A,	Example Problem solving

	jacking, Fast-flux, Rock phish, Dynamic ip addresses, Spam, Botnets, irc, p2p, encrypted channels		
Anti-cybercrime strategies	Cybercrime legislation as an integral part of a cyber security strategy. A cybercrime policy as starting point role of regulators in fighting cybercrime	Lecture, Q/A	Example problem solving
Cyber-control, Cyber-property, Cyber rights, Cyber-speech	Defining cyberspace, Internet Governance, The problem of jurisdiction. and the challenges of policing cyberspace defining cyber property, digital rights and ownership. Human rights and intellectual property intermediary liability, data privacy, right to be forgotten-Google case harmful speech and defamation	Lecture, Q/A	Example problem solving
Intellectual property law	International Intellectual property law. Intellectual property law and act in Bangladesh.	Lecture, Q/A	Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Cybercrime and the Law: Challenges, Issues, and Outcomes by Susa W. Brenner

CSE 531 PROGRAMMING WITH C

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: Students studying CSE should have the basic knowledge of Computer Programming. C language is the base of all other programming languages. This course provides basic knowledge on C programming language.

Objectives:

1. To introduce the concept of computer programming with in detail coverage of basic building blocks - variables, control structures, operators and expressions, function, pointers, arrays and strings, file i/o, etc.
2. To make the students understand how computer language affects the operation of the computer.
3. To improve the analytical and problem solving skill of the students.
4. It is expected that the students will be able to write moderately complex programs by the end of the semester.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
Introduction to C language, its history, basic operations, data types, variables, keywords, inputs & outputs	**Example from books,** Rules for variable naming **Simple C programs,**	Lecture, Q/A,	Assignment, writing simple C program, Error correction
Arithmetic expressions, Arithmetic operators, Conditional statements, Relational & Logical operators, The switch-case conditional statement,	**Different types of operators, increment/decrement operator, conditional statements (if/else, nested if/else conditions)**	Lecture, Q/A	Simple program using different types of operators, Problem solving using conditional statements
Repetition statements: different types of loops, use of loops, Nested loops, Use of break and continue;	**While loop, Do-while loops, for loop, differences between those loops.**	Lecture, Q/A,	Assignment on problems using loops.
Introduction to Array & String. 1D array, 2D array. Advantages of Arrays. Different kind of array operations.	**Array input/output, Array Reverse, Searching operations, sorting, 2D array problems,**	Lecture, Q/A,	Problem solving with Arrays &Strings,
Functions, Scope of Variables, Dynamic memory allocation, Passing parameters to function: Call-by-value vs. Call-by-reference, Recursion	Local & Global Variables, Function Calling, Base Case / Recursive case of Recursion, Basic problems using functions and recursion	Lecture, Q/A	Problem solving using functions & recursions
Pointers & Structures	Basic of pointers, uses of structures, object basic,	Lecture, Q/A	Assignment

	difference between union and structure		
File, Bitwise Operators, The Shift Operators	Basic file I/O, and /or/ not / shift operators,	Lecture, Q/A	Assignment on file & bitwise operator

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. C: The Complete Reference, McGraw-Hill, Fourth Edition by Herbert Schildt
2. Programming with C by Byron Gottfried

Recommended text books:

1. David Griffiths, Dawn Griffiths: Head First C, O'REILLY, 2012

CSE 533 DATA STRUCTURE

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: The study of data structure is an essential part of virtually every under graduate and graduate program in computer science. Data structure is a logical and mathematical model of storing and organizing data in a particular way in a computer. In system programming and application programming the methods and techniques of data structures are widely used. The study of data structure helps the students in developing logic and structured program.

Objectives: The overall objective of this course is equip the student with a set of tools, including analytical skills, that will enable him/her to create programming solutions for real world problems. As programming involves the manipulation of data, it is important to be able to analyze, design, program (apply the design), and select the appropriate data structures required to solve specific problems.

Upon the successful completion of this course students will be able to:

- Apply data abstraction in programming problems.
- Become proficient at evaluating the benefits and drawbacks of their design in terms of memory and run time efficiency.
- Program using arrays and linear linked lists, circular linked lists, doubly linked lists, binary search trees, arrays of linear linked lists.
- Apply recursion and key transformations.
- Make judgments about the practical and social application of algorithm concepts.

Intended Learning Outcomes(ILOs)	Course Content	Teaching/ Learning Strategy	Assessment Strategy
Introduced to Data Structure. Basic terminology and operations. Understanding algorithm, complexity and time-space	**Data structure and their types (Linear, non-linear).** Data structure terminologies. Algorithm & time space	Lecture, Q/A,	Assignment,

tradeoff.	complexity.		
Linear data structure-Array. Understanding the concept and use of array. Memory organization of array. Array manipulation.	Array, Array algorithms- Insert, delete, traverse Multi-dimensional array, Pointer array	Lecture, Q/A, Multimedia Slides	Problem solving using Array. Write programs to store and manipulate data using Array
Applying searching and sorting algorithms using array. Understanding the performance, limitation and improvement of these algorithms.	Linear search algorithm, Bubble sort algorithm, Binary search algorithm	Lecture, Q/A, Multimedia Slides	Assignment/ Quiz, Problem solving
Understanding the concept of Linked List, representation of Linked List in memory. Importance of Linked List over array. Inserting, deleting, traversing and searching in Linked List.	Linked List, Structure of node, Inserting- - Insert into head - Insert into tail - Insert into given position - Delete from head - Delete from tail - Delete selected node - Traverse/find	Lecture, Q/A, Multimedia Slides	Assignment/ Quiz
Understanding Stacks and Queue. Applying Stack and Queue to solve problems.	**Stacks, Push & Pop algorithm, overflow/underflow, postfix expression/polish notation, Recursion, Tower of Hanoi, Divide and conquer algorithm, Queue, Deques and Priority queues.**	Lecture, Multimedia Slides, Q/A	Assignment, Problem solving using Stack and Queues.
Understanding non-linear data structure- Tree, terminologies, memory representation of tree. Searching and sorting using tree structure.	**Trees,** **Binary Trees-** - Traversing a Binary Tree (Preorder, post order and in order traversal) **Binary Trees-** - Insert, delete and searching in Binary Tree Heap Sort- - Heap	Lecture, Multimedia Slides, Q/A	Assignment, Quiz

	- Insert and delete from heap - Sort array with heap		

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Theory and Problems of Data Structures, Scaum's Outline Series.By Seymour Lipscutz
2. Handbook of Data Structures and Applications By Dinesh P. Mehta, Dinesh P. Mehta, Sartaj Sahni

Recommended text books:

1. Data Structures and Algorithms Made Easy By Narasimha Karumanchi
2. Fundamentals of Data Structures in C by Ellis Horowitz and Sartaj Sahni

CSE 535 COMPUTER NETWORK

Credit Hours: 3, **Contact Hours**: 3 per week **Marks:** 100

Rationale: This course is to provide students with an overview of the concepts and fundamentals of data communication and computer networks and provides the student with fundamental knowledge of the various aspects of computer networking and enables students to appreciate recent developments in the area. Topics to be covered include: data communication concepts and techniques in a layered network architecture, communications switching and routing, types of communication, network congestion, network topologies, network configuration and management, network model components, layered network models (OSI reference model, TCP/IP networking architecture) and their protocols, various types of networks (LAN, MAN, WAN and Wireless networks) , routing protocols, bridges, routers and gateways; network naming and addressing; and local and remote procedures. On completion of the course, the student should be able in part to design, implement and maintain a typical computer network (LAN).

Objectives: At the end of the course, the students will be able to:

1. Build an understanding of the fundamental concepts of computer networking.
2. Familiarize the student with the basic taxonomy and terminology of the computer networking area.
3. Introduce the student to advanced networking concepts, preparing the student for entry advanced courses in computer networking.
4. Allow the student to gain expertise in some specific areas of networking such as the design and maintenance of individual networks.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
1. Understand the IP addressing. 2. Internet Protocol: Ipv4-32 bit and IPV6-128 bit. 3. Understand the five IPv4 classes of IP addresses with the range of IP addresses and the default subnet mask for each class. 4. How to identify the Network ID, host ID, and the default gateway address to determine local and non-local hosts. 5. Understand the difference between a public IP address and a private IP address. 6. Understand about IVP4 Subnetting.	Chapter 5. Internet Protocol Addresses IPV4 Addressing 1.1 What is an IP address? Why do we need IP address? 1.2 Address Architecture of the Internet. IP Address Structure: Network portion and Host portion. IP addresses can be grouped into one of five different classes. 1.3 Discuss of the Class A,B,C,D and D Address Including First Octet Range, Number of Possible networks, Number of possible hosts per network and Broadcast Address. 1.4 Number system and conversions of each number. What is mask and why it is needed? Discuss Private IP address and Unique IP Address. 1.5 Find out the parameters from a given IP addresses: Class, Default mask, No. of usable subnets, No. of hosts/subnet, Subnet Id, Subnet work mask, IP exits in subnet no, CIDR notation of given IP, Usable Hosts, and Broadcast address.	Lecture, Discussion, Problem based learning, Exercise	Do

1. Identify the necessary computer component used in configuration. 2. Determine the functions of each computer component used in configuring. 3. Give the most important component that plays a vital role in a network. 4. To use technology to optimize their use for learning and productivity.	Chapter 7. Network Hardware 1.1 Introduction Introduction to the Computers of a Network 1.2 Computer Accessories and Peripherals ✔ Keyboard and Mouse ✔ Monitors ✔ Printers Network Distribution ✔ Introduction ✔ Network Cables 1.3 Ethernet at the data link layer ● Ethernet addressing ● Ethernet Frames Ethernet at the Physical layer. 1.1 Ethernet Cabling	Lecture, Discussion, Problem based learning, Exercise	Do
1. Describe Ethernet topology. 2. Explain how CSMA/CD is used within an Ethernet LAN. 3. Compare and contrast two Ethernet frame types. 4. Describe the relationship between IEEE Ethernet standards and the OSI model. 5. Troubleshoot an	Chapter 8. Ethernet Fundamentals 1.1 Ethernet Networks introduction and its function. Collision Domain 1.2 Broadcast Domain CSMA/CD Half and Full-Duplex Ethernet 1.3 Ethernet at the data link layer ● Ethernet addressing ● Ethernet Frames Ethernet at the	Lecture, Discussion, Problem based learning, Exercise	Do

Ethernet problem.	Physical layer.		
1. Data Encapsulation Fundamentals 2. Protocol Data Unit (PDU) 3. OSI Layer Model and PDUs 4. Troubleshoot an Ethernet problem.	Chapter 9. Data Encapsulation 1.1 Introduction of Data Encapsulation Process Protocol Data Unit (PDU) 1.2 OSI Layer Model and PDUs and Its function 1.3 Encapsulation process ✔ TCP Header Encapsulation ✔ IP Header Encapsulation ✔ MAC Header Encapsulation ✔ Physical Layer Encapsulation ✔ De-Encapsulation	Lecture, Discussion, Problem based learning, Exercise	Do
1. What are VLAN's? 2. Design VLAM's 3. Why use VLAN's? 4. How VLAN's work 5. Types of VLAN's 6. Types of Connections 7. Frame Processing 1. Understand the IOS User interface 2. Connecting to a Cisco IOS Device 3. How to bringing Up a switch	Chapter 10. VLAN (Virtual Local Area Network) 1.1 Introduction of VLANs Design VLANs 1.2 What are VLANs? Why use VLAN's? 1.3 How VLAN's work Types of VLAN's Chapter 11. Internetworking operating System (IOS) 1.1 Introduction to Internetworking Operating system Cisco's IOS 1.2 Connecting to a Cisco IOS Device Bringing Up a Switch 1.3 Command Line Interface (CLI)	Lecture, Discussion, Problem based learning, Exercise	Do

Command Line Interface (CLI)	✔ Entering the CLI ✔ Overview of Router Modes ✔ CLI Prompts ✔ Interfaces ✔ Routing Protocol Configurations ✔ Editing and Help Features		
1. Understand the Administrative Configurations 2. Router and Switch Interfaces Viewing , Saving ,and Erasing Configurations	Chapter 12. Internetworking operating System (IOS) 1.1 Internetworking operating System (IOS) 1.2 Administrative Configurations ● Hostnames ● Banners ● Passwords ● Interface description 1.3 Router and Switches Interfaces ● Bringing up an Interface ● Configuring an IP Address on an Interface ● Serial Interface commands	Lecture, Discussion, Problem based learning, Exercise	Do
1. Understand the routing basic concept. 2. Describe the primary functions and features of a router. 3. Describe the Routing Classifications. 4. Explain how routers use information in data	Chapter 14.Routing Protocol 1.1 Definition of routing protocol. Describe the primary functions and features of a router. 1.2 Functions of Router 1.3 Describe the Routing	Lecture, Discussion, Problem based learning, Exercise	Do

packets to make forwarding decisions in a small to medium sized network. 5. Compares ways in which a router builds table when operating in a small to medium sized business network.	classifications. Explain the Static and Dynamic Routing. 1.4 Configure Basic Router Settings Configure a loopback interface Verify Interface Settings Command History Feature Routing Table Sources		
1. Understand the Static Routing Implementation. 2. Configure Static and Default Routes 3. Review of CIDR and VLSM 4. Configure summary and Floating Static Routes 5. Troubleshoot Static and Default route issues	Chapter 15. Static Routing Protocol 1.1 Definition of Static Routing. Explain the advantage and disadvantages 1.2 Explain the purpose of different types of static routs. Configure IPv4 and IPv6 static routes by specifying a next-hop address. 1.3 Explain the purpose of CIDR in replacing classful addressing. Explain the use of legacy classful addressing in network implementation. Configure an IPv4 and IPv6 default routes. 1.4 Troubleshoot common static and default route configuration issues. Explain how a router processes packets when a static route is configured.	Lecture, Discussion, Problem based learning, Exercise	Do
1. Describe how a router determines a path and switches packets 2. Describe the structure of a routing table. 3. Demonstrate the ability to configure	Chapter 16. Routing Information Protocol (RIP) 1.1 Definition of Routing Information Protocol (RIP) Router as a Computer 1.2 Configure Devices and apply Address	Lecture, Discussion, Problem based learning, Exercise	Do

devices and apply addresses. 4. Identify a router as a computer with an OS and hardware designed for the routing process.	Routing Table Structure 1.3 Router path and packet Switching summery		
1 RIP routing updates 2 RIP routing metric 3 RIP scalability and limitations 4 RIP stability features 5 Configuring RIP	Chapter 17. Routing Information Protocol (RIP) 1.4 RIP Fundamentals RIP routing updates RIP routing metric 1.5 RIP Scalability and Limitations RIP Stability Features 1.6 Configuring RIP	Lecture, Discussion, Problem based learning, Exercise	Do
1 Describe the operation and configuration of EIGRP, including load balancing and authentication. 2 Identify an approach for troubleshooting common EIGRP problems and offer solutions	Chapter 18. Enhanced Interior Gateway Routing Protocol(EIGRP) 1.1 EIGRP Fundamentals EIGRP Features 1.2 EIGRP Components EIGRP Concept 1.3 EIGRP Configuration Command	Lecture, Discussion, Problem based learning, Exercise	Do
1. Describe the role of dynamic routing protocols and place these protocols in the context of modern network design. 2. Identify several ways of classify routing protocols. 3. Describe how metrics are used by routing protocols and identify the metric types used by dynamic routing	Chapter 19. Dynamic Routing 1.1 Definition of Dynamic routing. Classifications of Dynamic routing. Difference between static and dynamic routing. 1.2 RIPV1 and RIV2 routing. EIGRP routing, OSPF routing 1.3 Identify the different elements of the routing table.	Lecture, Discussion, Problem based learning, Exercise	Do

protocols.			
1. Describe OSPF terminology and operation within various enterprise environments. 2. Describe the function and operation of packets in OSPF routing. 3. Configure and verify basic OSPF. 4. Describe and configure OSPF in various WAN network types. 5. Configure and verify advanced OSPF features.	Chapter 20. Open Shortest Path Fast (OSPF) 1.1 OSPF Fundamentals OSPF Features 1.2 Adjacency and Designated Routers Link State Advertisements OSPF Packet Types 1.3 OSPF States OSPF Metrics Routing with OSPF	Lecture, Discussion, Problem based learning, Exercise	Do
1. Configure and verify basic OSPF. 2. Describe and configure OSPF in various WAN network types. 3. Configure and verify advanced OSPF features. 4. Configure and verify OSPF authentication.	Chapter 21. Open Shortest Path Fast (OSPF) 1.4 Address less Interfaces Using OSPF and RIP 1.5 Importing BGP routes into OSPF OSPF On Demand Circuits 1.6 OSPF Configuration Configure and verify advanced OSPF features. Configure and verify OSPF authentication.	Lecture, Discussion, Problem based learning, Exercise	Do
1. Identify the characteristics of distance vector routing protocols. 2. Describe the network discovery process 3. Identify the conditions leading to a	Chapter 22. Distance Vector Routing Protocol 1.1 Distance Vector Routing Protocol Fundamentals Distance Vector Routing Protocol Features Examples of Distance Vector routing protocols	Lecture, Discussion, Problem based learning, Exercise	Do

routing loop and explain the implications for router performance. 4. Recognize that distance vector routing protocols are in use today.	1.2 Characteristics of Distance Vector routing protocols Routing Protocol Algorithm 1.3 Advantages and Disadvantages of Distance Vector Routing Protocol Network Discovery Routing Table Maintenance Routing Protocols Today		
1. Describe the factors that led to the development of IPv6 and possible uses of this new IP structure. 2. Describe the structure of the IPv6 address format, how IPv6 interacts with data link layer technologies, and how IPv6 is supported in Cisco IOS Software. 3. Implement IPv6 services and applications.	Chapter 23 .IPV6 1.1 What are the parts of an IPv4 address? What is the purpose of the subnet address? Describe the factors that led to the development of IPv6 and possible uses of this new IP structure. 1.2 Describe the structure of the IPv6 address format, how IPv6 interacts with data link layer technologies, and how IPv6 is supported in Cisco IOS Software. Implement IPv6 services and applications.	Lecture, Discussion, Problem based learning, Exercise	Do

Text Books:

1. Computer Network, Tanenbaum
2. Data Communications and Networking ,3rd Edition, Behrouz A. Forouzan

CSE 537 OBJECT ORIENTED PROGRAMMING

Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: Students studying CSE need to focus on fundamental concepts and principles used in object oriented programming which are areas of immense interest in recent time. This is a graduate course on object oriented programming with an emphasis on understanding mechanisms that help to implement the object oriented model. This course introduces the concepts of object-oriented programming to students with a background in the procedural paradigm.

Objectives:

(1) To provide students with an introduction to object oriented programming (OOP) using the Java programming language.

(2) To teach students the basic concepts and techniques which form the object oriented programming paradigm.

(3) Write, compile and execute Java programs

(4) Build robust applications using Java's object-oriented features

(5) Create robust applications using Java class libraries

(6) Develop platform-independent GUIs

(7) Read and write data using Java streams

(8) Retrieve data from a relational database with JDBC

(9) To develop an understanding of

- The object oriented way of programming.
- The fundamental elements of OOP and related Java features.
- Writing robust, industrial-strength Java code.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
Introduced to fundamental programming structures in Java, Able to learn the basics of the Java programming language.	The main() method, Primitive data types, Array and References, Variables, Constants, Initializations, Operators and constructs, Dynamic memory allocation, java methods, Strings, Control Flow.	Lecture, Q/A, Code Examples	Problem solving, Assignment
Introduced to Classes and Objects in Java, Able to learn the fundamental elements of OOP and related Java features.	Field & access control, Classes & objects, OOP principles, Instance variables, Class variables, Constructors, static methods, Instance methods, Class	Lecture, Q/A, Code Examples	Problem solving, Assignment

	methods, Method overloading, Passing and returning objects, Garbage collection in Java.		
Introduced to object design and programming with Java, Able to understand the object oriented way of programming.	Abstraction, Inheritance, Polymorphism, Method overriding, Dynamic Binding	Lecture, Q/A, Code Examples	Problem solving, Assignment
Introduced to Java Interfaces, Able to create high levels of abstraction.	Purpose of Interfaces, When to use them, Interface declaration, implementing an Interface, Interface inheritance.	Lecture, Q/A, Code Examples	Problem solving, Assignment
Introduced to Java exception handling, Able to write robust, industrial-strength Java code.	Why exceptions? Standard exception handling options, Exception class hierarchy, catching an exception: try and catch blocks, Methods which throw exceptions: the throws clause, Handling vs. declaring exceptions, System exceptions vs. application exceptions, writing custom exceptions.	Lecture, Q/A, Code Examples	Problem solving, Assignment
Introduced to Thread. Explain the states of thread, Discuss about thread class and timer thread. Show the Implementing the Runnable interface	Thread states, Extending the thread class, Timer Thread, Implementing the Runnable interface	Lecture, Q/A, Code Examples	Problem solving, Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Herbert Schildt: Java – The Complete Reference, 7th Edition
2. An Introduction to Object-Oriented Programming with Java By C. Thomas wu

Recommended text books:

1. Harvey M. Deitel and Paul J. Deitel: Java – How to Program, 9th Edition

2. OOP: Learn Object Oriented Thinking and Programming by Rudolf Pecinovsky

CSE 539 DATABASE MANAGEMENT SYSTEM
Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: Database Management Systems (DBMS) are vital components of modern information systems. Database applications are pervasive and range in size from small in-memory databases to terra bytes or even larger in various applications domains. The course focuses on the fundamentals of knowledgebase and relational database management systems, and the current developments in database theory and their practice.

Objectives:

(1) To understand the different issues involved in the design and implementation of a database system

(2) To study the physical and logical database designs, database modeling, relational, hierarchical, and network models

(3) To understand and use data manipulation language to query, update, and manage a database

(4) To develop an understanding of essential DBMS concepts such as: database security, integrity, concurrency, distributed database, and intelligent database, Client/Server (Database Server), Data Warehousing

(5) To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementing a DBMS.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
Students should be able to: ● Differentiate between data and information. ● Define the following key terms: database, Database Management System (DBMS), metadata, data inconsistency, query, single user database, multi-user database, enterprise database, centralized database, distributed database, operational database, data warehouse, data integrity, data anomaly, query language, Structured Query Language (SQL).	Introduction to the Course Database Systems: ● Differences between data and information. ● Types of databases and their value for decision making. ● Importance of database design. ● Database roots in file systems. ● Problems with file system data management. ● Differences between databases and file systems.	Lecture, Q/A, PowerPoint Slides	Assignment

• Describe briefly the different types of databases and explain why they are important. • Explain the importance of database design. • Explain the terms structural dependence and data dependence. • Differentiate between logical and physical data formats. • List and briefly describe the main components of a database system. • Define the term data redundancy and explain its effects on the quality of information produced. • Differentiate among update anomaly, insertion anomaly, and deletion anomaly. • Explain how a database system differs from a file system. • List the main functions of a database management system.			
Students should be able to: • Define the following key terms: attributes, relationship, constraint, business rule, entity instance, connectivity, schema, external schema, conceptual schema, internal schema. • Explain why data models are important. • Describe the basic building blocks of all data models. • Explain why identifying and documenting business rules is essential to database design. • Explain how the major data models evolved. • Explain the purpose and origin of the three levels of	Data Models: • The importance of data models. • The basic building blocks of data models. • The relationship between data models and business rules. • The evolution of data models. • Classifying data models by degree of abstraction	Lecture, Q/A, PowerPoint Slides	Assignment

data abstraction: external, conceptual, and internal.			
Student should be able to: ● Explain how relational database enables data to be viewed logically rather than physically. ● Explain the characteristics of relational tables. ● Define the following key terms: key, super key, candidate key, primary key, secondary key, foreign key, entity integrity, and referential integrity. ● Identify and apply entity integrity and referential integrity rules.	The Relational Database Model (RDBMS): ● A Logical View of Data. ● Keys. ● Integrity Rules. ● Relational Set Operators. ● The Data Dictionary and the System Catalog. ● Relationships within the Relational Database. ● Data Redundancy Revisited. ● Indexes.	Lecture, Q/A, PowerPoint Slides	Assignment
Students should be able to: ● Define the following terms: entities, attributes, domain, composite primary key, simple attribute, composite attribute, single-valued attributes, multi-valued attributes, and derived attributes. ● Identify and provide suitable name that is descriptive of the relationship. ● Differentiate between weak and strong relationships.	Entity Relationship (ER) Modeling: ● The Entity Relationship (ER) model (entities, attributes, relationships, connectivity and cardinality, existence dependence, relationship strength, weak entities, relationship participation, relationship degree, recursive relationships, composite entities) ● Developing an ER Diagram. ● Database Design Challenges: Conflicting Goals.	Lecture, Q/A, PowerPoint Slides	Assignment
Student should be able to: ● Differentiate between Data Definition Language (DDL) and Data Manipulation Language (DML). ● Describe some essential SQL DDL and DML commands. ● Interpret and use different data types. ● Apply SQL DDL commands	Introduction to SQL ● Data Definition Commands. ● Data Manipulation Commands. ● Select Queries. ● Advanced Data Definition Commands. ● Advanced Select Queries.	Lecture, Q/A, PowerPoint Slides	Project work

to create tables, views, and indexes. ● Apply SQL DML commands to select, insert, update, and delete data. ● Explain and use logical operators AND, OR, NOT ● Use special operators such as BETWEEN, IS NULL, LIKE, IN, and EXISTS in conjunction with the WHERE clause. ● Explain and use the aggregate functions: COUNT, MAX, MIN, SUM, and AVG for mathematical summaries. ● Use the ALTER command to add a column and drop a column. ● Use the DROP TABLE command to delete a table from the database. ● Use the ORDER BY clause to sort a listing in ascending or descending order. ● Use the GROUP BY clause in conjunction with an SQL aggregate function such as COUNT, MIN, MAX, AVG, and SUM to obtain summary row data, or subtotals in reports.	● Virtual Tables: Creating a View. ● Joining Database Tables.		
Student should be able to: ● Know about File Organization and Indexes ● Understand Tree-structured Indexing: B+-trees ● Learn Hash-based Indexing – Indexes in PostgreSQL	Data Storage and Indexing ● File Organization and Indexes ● Tree-structured Indexing: B+-trees ● Hash-based Indexing – Indexes in PostgreSQL	Lecture, Q/A, PowerPoint Slides	Project work
Student should be able to: ● Know the purpose of normalization.	Normalization: ● Purpose of	Lecture, Q/A, PowerPoint Slides	Project work

• Understand how normalization supports database design. • Know about Data redundancy and update anomalies • Understand Functional Dependency, The process of normalization • Learn about 1NF, 2NF and 3NF	normalization. • How normalization supports database design. • Data redundancy and update anomalies • Functional Dependency • The process of normalization • 1NF, 2NF and 3NF		

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Database System Concepts, 6th editions Henry F Korth, Abraham Silberschatz, S Sudharshan
2. Database Systems: An Application Oriented Approach, Compete Version, 2nd Edition
   Michael Kifer, Arthur Bernstein, Philip M. Lewis

Recommended text books:

1. Fundamentals of Database Systmes,6th edition.RamezElmarsi, Shamkant B. Navathe

Oracle SQL Interactive Workbook, Prentice Hall PTR, 2000.Alex Morison

CSE 541 OPERATING SYSTEM

Credit Hours: 3**, Contact Hours**: 3 per week **Marks:** 100

Rationale: Operating systems are central to computing activities. An operating system is a program that acts as an intermediary between a user of a computer and the computer hardware. Two primary aims of operating systems are to manage resources (e.g. CPU time, memory) and to control users and software. Operating system design goals are often contradictory and vary depending of user, software, and hardware criteria. This course describes the fundamental concepts behind operating systems, and examines the ways that design goals can be achieved.

Objectives: The student will be taught principles of modern operating systems. In particular, the course will cover details of concurrent processes, multi-threads, CPU scheduling, memory management, file system, storage subsystem, and input/output management, the course will integrate theory and practice through coordinated lecture and lab hours.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning**	**Assessment**

		Strategy	Strategy
Get overview of operating system, its history, how it is developed and its architectures.	The roles of an operating system. Historical overview of operating system development. Operating system architectures.	Lecture, Q/A,	
Learning various CPU scheduling algorithms. The difference between threads and processes. And the synchronization of process.	Processes and threads. Process Synchronization. Deadlocks. CPU scheduling.	Lecture, Q/A,	Problem solving. Assignment.
Analyzing memory management in operating system, file system architecture and etc.	Memory management. Virtual memory. File-system interface. File-system implementation.	Lecture, Q/A	Assignment
Learning how I/O works in operating systems.	Input Output systems.	Lecture, Q/A,	Assignment
Analyzing distributed system architecture, distributed file system.	Network and distributed system structures. Distributed file systems	Lecture, Q/A,	Problem solving, Assignment

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Operating System Concepts, Addison-Wesley (5th ed.) by Abraham Silberschatz and Peter Baer Galvin
2. Operating Systems: Principles and Practice by Thomas Anderson and Michael Dahlin

Recommended text books:

1. Operating Systems: Design and Implementation, Prentice Hall (2nd ed.)
   Andrew S. Tanenbaum and Albert S. Woodhull
2. Operating Systems: Internals and Design Principles :William Stallings

CSE 543 COMPUTER ARCHITECTURE

Credit Hours: 3**Contact Hours**: 3 per week **Marks:** 100

Rationale: Students studying CSE need to focus on fundamental concepts and techniques used in computer designing which are areas of immense interest in recent time. This is a graduate course on computer architecture with an emphasis on a quantitative approach to cost/performance design tradeoffs. This course provides basic knowledge on different computer architectural techniques and methods.

Objectives:

(1) To provide students with fundamental knowledge and techniques in computer designing.
(2) To develop an understanding of

- How a modern computer works.
- How it supports execution of software.
- How design alternatives affect performance and cost.

(3) To develop the problem-solving skills associated with the application of these methods in practical, real data processing, and learn how to extract verifiable information from such applications.

Intended Learning Outcomes(ILOs)	**Course Content**	**Teaching/ Learning Strategy**	**Assessment Strategy**
Introduced to Fundamentals of Computer Design, Able to measure and report performance, Able to compare two design alternatives.	**Task of the computer designer, Basic quantitative principles of computer design, Measuring and reporting performance.**	Lecture, Q/A	Problem solving, Assignment
Able to classify instruction set architectures, Introduced to memory addressing, Able to identify different addressing modes.	**Classification of instruction set architectures, Memory addressing, addressing modes.**	Lecture, Q/A	Problem solving, Assignment
Introduced to memory hierarchy design, Able to calculate cache performance, Understand the different trade-offs of memories at different levels of a hierarchy.	**Memory hierarchy design, Cache hit/miss, miss rate and miss penalty, Memory stall cycles, Four memory hierarchy questions, Memory technology, Virtual memory.**	Lecture, Q/A	Problem solving, Assignment
Understand storage systems, Able to classify buses, Analyze the performance of storage systems.	**Classification of buses, Bus design decisions,** Module reliability, availability and dependability**, MTTF, MTTR, RAID.**	Lecture, Q/A	Problem solving, Assignment
Understand pipelining, Able to compare performance between a pipelined processor and a processor that is not pipelined, Detect	**Concept of pipelining, Pipeline hazards,** A simple implementation of a basic five-stage	Lecture, Q/A	Problem solving, Assignment

and resolve hazards that make pipelining hard to implement.	RISC pipeline, Speedup in the instruction execution rate gained from a pipeline.		

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Computer Architecture – A Quantitative Approach, 3rd Edition John L. Hennessy, David A. Patterson
2. Computer Architecture: Fundamentals and Principles of Computer Design Joseph D. Dumas II, Joseph D. Dumas II

Recommended text books:

1. Computer Architecture and Organization, 3rd Edition, McGraw Hill John P. Hayes
2. Computer Organization and Architecture: Designing for Performance, 8th Edition William Stallings

CSE 545 COMPUTER ALGORITHM

Credit Hours: 3**Contact Hours**: 3 per week **Marks:** 100

Rationale: This course will introduce the students to algorithms in a variety of areas of interest, such as asymptotic analysis, sorting, dynamic programming, divide-and-conquer algorithms, greedy algorithms and graph algorithms. They will learn to study the performance of various algorithms within a formal, mathematical framework. They will also learn how to design very efficient algorithms for many kinds of problems.

Objectives:

- Analyze the asymptotic performance of algorithms.
- Demonstrate a familiarity with major algorithms and data structures.
- Apply important algorithmic design paradigms and methods of analysis.
- Synthesize efficient algorithms in common engineering design situations.

Intended Learning Outcomes(ILOs)	Course Content	Teaching/ Learning	Assessment Strategy

		Strategy	
Able to define algorithms, find complexity & understand the differences among different notations of complexity	Definition of algorithms, complexity Growth of function: Asymptotic notations, Standard notations.	Lecture, Discussion	Q/A, feedback
Able to understand the differences between $O(n^2)$ time sorting algorithms &$O(n\ log\ log\ n)$ time sorting algorithms. Able to understand and write programs the follwing algorithms: Bubble sort, Selection sort, Insertion sort, Merge sort, Heaps and heap sort, Quick sort.	$O(n^2)$Time sorting algorithms, $O(n\ log\ log\ n)$Timesorting algorithms.	Lecture, Q/A	Write programs for these algorithms, quiz
Understand Top-down and bottom-up Dynamic programming , able to Understand & code Matrix chain multiplication, 0/1 knapsack, Coin change problem, Longest Common Sequence (LCS), Longest Increasing Subsequence (LIS).	Dynamic programming	Lecture, Q/A, feedback	Write programs for these algorithms, quiz
Understand & code Breadth-first search (BFS), Depth-first search (DFS), Topological sort & find Strongly Connected Components (SCC) etc.	Graph algorithms.	Lecture, Q/A, feedback	Assignment
Understand the differences between Prim's algorithm & Kruskal's algorithm & able to write program.	Minimum Spanning Trees (MST).	Lecture, Q/A, feedback	Write programs for these algorithms
Understand the differences between The Bellman-Ford algorithm &Dijkstra's algorithm & able to write program.	Single-source shortest paths:	Lecture, Q/A, feedback	Assignment

Understand &code The Floyd-Warshall algorithm.	All-pair shortest paths: The Floyd-Warshall algorithm.	Lecture, Q/A, feedback	Write programs for the algorithms

RECOMMENDED BOOKS AND REFERENCES

Text books:

1. Introduction to Algorithms By Thomas H. Cormene. El.
2. Data Structures and Algorithms By: Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft

Recommended text books:

1. Algorithms 1st Edition by Sanjoy Dasgupta
2. The Design and Analysis of Algorithms (Monographs in Computer Science), by Dexter C. Kozen

Curriculum Prepared by:

Academic Committee, Department of Computer Science & Engineering, Leading University.

External Subject Expert:

1. Professor Dr. Mohammad Shahidur Rahman, Director, ICT, SUST.
2. Dr. Md. Forhad Rabbi, Associate Professor, Department of CSE, SUST.

APPENDIX A

ROLE AND RESPONSIBILITIES OF THE SUPERVISOR

1. Before starting, the supervisor to the candidate will need to know the latest university rules and regulations relating to higher degree programs.

2. Supervisors should have adequate knowledge, enhanced theoretical and conceptual framework, and is up to date in the field of research of the candidate.

3. Supervisors should be knowledgeable about the work schedule provided for the completion of a research project so that it complies with the provisions of certain degrees. This is to ensure the smooth running of the candidate's research project.

4. Supervisors are responsible for providing relevant and adequate guidance and academic support to students during the supervision period to enable the candidate to carry out excellent research and writing. This responsibility includes guiding the careful planning of the research, the background and library research, the need to attend courses to complete the research, including scientific methods. Awareness about the impact of fraud and plagiarism should be informed to the candidate.

5. Supervisors should interact with the candidate at least two (2) times per month in the first semester and once (1) a month for the next semester. For the first meeting, the supervisor and the candidate must talk face to face, while, the next meeting may be conducted via other methods such as on-line.

6. Supervisors are responsible to ensure that candidates could communicate with relevant experts should the research area requires so. In certain cases, an additional supervisor or consultant may be appointed.

7. Each supervisor should be appointed to the candidates should know their responsibilities respectively and explained to the candidates on the aspects that will be monitored. In the event that two (2) supervisors were appointed for each candidate, the effective working relationship between all parties needs to be maintained together.

8. Supervisors need to help candidates in the preparation with regards to the presentation at conferences, seminars, meetings and workshops.

9. Supervisors are encouraged to record every meeting and discussion with the candidate about the study and research of the candidate by providing and updating the file on record of achievement and progress of research projects for each candidate.

10. Supervisors should evaluate the progress of the candidates by getting a written report and monitor the performance in a relative manner according to the quality set for a certain degree. Candidates should be informed if the quality of her work did not reach the required standard. If progress of the candidates is not satisfactory, the supervisor must take action to help the candidates improve their performance. Progress report for each semester for each candidate must be submitted by the supervisor to the Academic / Faculty / Institute / Centre as scheduled.

11. Supervisors should help candidates in academic writing, presentations in conferences and submitted for publication. For all the academic papers submitted for publication, written jointly by the supervisor and candidate, both have to agree to publish them together.

12. Supervisors need to help manage and secure any funds for research projects.

13. Supervisors must ensure work safety rules are followed during the research and are carried out in accordance with health and safety ethics policy specified by the University.

14. Supervisors should provide constructive and critical comments on the candidate's drafts of the thesis within a reasonable time and advise the candidate regarding the format of the thesis as specified by the University.

The Role of Supervisor in the Board of Examiners

1. The role of supervisor in the Board of Examiners is as the advisor. The supervisor is not involved in any discussions relating to the results of work submitted by the candidate. The supervisor does not function as an examiner.

2. The supervisor's attendance in the Board of Examiners shall be by invitation only.

3. Supervisors are expected to provide supervision reports in the required format within a specified time.

APPENDIX B

ROLE AND RESPONSIBILITIES OF THE CANDIDATE

1. Candidates should interact with the supervisor at least two (2) times per month in the first semester and once (1) a month the next semester. For the first meeting, the candidate and supervisor should talk face to face, while, the next meeting can be conducted via other methods such as online.

2. Candidates shall record meetings and discussions on their research each time they meet with the supervisor.

3. Candidates should have a good working relationship with the supervisor.

4. Candidates must plan the project schedule and comply with the maximum period of study.

5. Candidates should discuss and agree with the supervisor on consultation times.

6. Candidates must submit progress as specified without falsifying the research outcome and is free of plagiarism.

7. Candidates must notify their supervisor of any problems that may interfere with the research.

8. Candidates shall engage in academic activities organized by the department.

9. Candidates must plan and ensure sufficient time to do the research and write the thesis.

10. Candidates should ensure that their candidature is always active by renewing their registration each semester.

11. A candidate shall give three months' notice to the supervisor or inform the supervisor the date for submission of the thesis for examination purposes, so there is no delay in the appointment of examiners.

12. Candidates are solely responsible for the content, the presentation of thesis and viva-voce presentation.

13. Candidates are responsible for ensuring that corrections are made in a given period after the Board of Examiner's meeting / viva-voce.