(ANNEXURE IX)

Appendix 'VIII'

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

SMIT

MAJITAR

COURSE CURRICULUM FOR M. TECH (CSE)ACCORDING TO NATIONAL EDUCATION POLICY-2020

APPLICABLE FOR 1st YEAR FROM 2022-23 BATCH

AND

SUBSEQUENT BATCHES

Total Credits:

Total Credits: 20 + 20 + 15+25 = 80

PROGRAM OUTCOMES

1. An understanding of the theoretical foundations and the limits of computing.
2. An ability to adapt existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
3. An ability to design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
4. Understanding and ability to use advanced computing techniques and tools.
5. An ability to undertake original research at the cutting edge of computer science & its related areas.
6. An ability to function effectively individually or as a part of a team to accomplish a stated goal.
7. An understanding of professional and ethical responsibility.
8. An ability to communicate effectively with a wide range of audience.
9. An ability to learn independently and engage in life¬long learning.
10. An understanding of the impact of IT related solutions in an economic, social and environment context

VISION AND MISSION OF SIKKIM MANIPAL INSTITUE OF TECHNOLOGY

VISION

- To achieve eminence in the field of quality technological education and research.

MISSION

- To develop SMIT into an Institution of Excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

OBJECTIVES

- To provide wholesome education to meet the intellectual aspirations of the students.
- To equip students with techno-managerial skills to enable them to take their assigned role in the industry.
- To inculcate essential ethics and values to meet the spiritual needs to the students.
- To provide a sound institutional environment nurturing emotional strength, healthy mind, body and resilience amongst the students.

VISION AND MISSION FOR DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Vision:

- To be among the nation's premiere research and teaching departments in Computer Science & Engineering.

Mission:

- Empower students to be successful, effective problem solvers, lifelong learners, ethical and positive contributors towards social and economic upliftment of the nation.
- Create, share and apply the knowledge acquired in Computer Science and interdisciplinary areas to benefit humanity.

PROGRAM EDUCATIONAL OBJECTIVES FOR M. TECH COMPUTER SCIENCE AND ENGINEERING DEGREE COURSE

The AICTE-approved B. Tech. Computer Science and Engineering degree course at SMIT/SMU provides the education and training necessary to design, implement, test, and hone skill sets as per the requirement of the changing trends of industries. The curriculum elaborates on all aspects of computer systems from Logic Design, Computer Organization & Architecture, Data Structures, Operating System concepts, Networking, Higher-Level Language Skills, Object Oriented Programming Concepts, Database Management System, Software Engineering, including electives ranging from mobile computing to data analytics and their applications.

The Computer Science and Engineering graduates are prepared for employment in a wide spectrum of high-technology industries and also to inculcate them to become successful professionals. The curriculum lays solid foundation in Computer Science enabling the graduates to work with engineers from other disciplines. Graduates are sufficiently prepared to continue life-long learning and equip themselves for higher qualifications and research activities worldwide.

The Program Educational Objectives of Computer Engineering program are:

- **Engineering Knowledge**: Our graduates will be capable of applying their engineering knowledgeto succeed in whichever field they want to pursue keeping abreast of the ever-changing technology.

- **Entrepreneurship:** Our graduates should be able to set up various entrepreneurship ventures whichin turn facilitate employability.

- **Research Upliftment:** Our graduates will apply the best practices of computation based on mathematics and science to address customized projects and ensure productivity in research.

- **Societal and Ethical Responsibility:** Our graduates will showcase a sense of societal and ethical responsibility in their professional endeavors and should be able to make an informed choice for the furtherance of the society.

- **Cognitive Communication**: Our graduates should be able to exhibit impromptu and impeccable communication skills with the potential of working as a team with cognitive empathy.

PROGRAM SPECIFIC OUTCOMES FOR M. TECH IN COMPUTER SCIENCE & ENGINEERING

PSO 1: Student should be adept in various recent trends offered in Computer Science & Engineering like Machine Learning, Augmented Reality, Internet of Things (IOT) and be efficient self-motivated learners confident with blended mode of Learning (MOOCS).

PSO2: Students should be able to pursue Project/ Example based learning and display a firm grasp on the technical knowhow of different subjects through measurable outcomes like publications, products, technical write up and so on.

M Tech in Computer Science and Engineering- 80 Credit

FIRST SEMESTER						SECOND SEMESTER					
Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
CS501A1	ADVANCED ALGORITHMS	2	1	0	3	CS502A1	THEORY OF COMPUTATION	2	1	0	3
CS5**A3	ELECTIVE-I	3	0	0	3	CS5**A3	ELECTIVE-V	3	0	0	3
CS5**A3	ELECTIVE-II	3	0	0	3	CS5**A3	ELECTIVE-VI	3	0	0	3
CS5**A3	ELECTIVE-III	3	0	0	3	CS5**A3	ELECTIVE-VII	3	0	0	3
CS5**A3	ELECTIVE-IV	3	0	0	3	CS5**A3	ELECTIVE-VIII	3	0	0	3
CS501A4	MACHINE LEARNING LAB	0	0	3	1.5	CS503A4	ADVANCED PROGRAMMING LAB	0	0	3	1.5
CS502A4	ADVANCED ALGORITHMS LAB	0	0	3	1.5	CS504A4	SOFTWARE AND DATA ANALYSIS LAB	0	0	3	1.5
CS501A5	PROJECT BASED LEARNING- I	0	0	4	2	CS502A5	PROJECT BASED LEARNING- II	0	0	4	2
		14	1	10	**20**			14	1	10	**20**
Total Contact Hours (L + T + P)		25				Total Contact Hours (L + T + P)		25			
THIRD SEMESTER						**FOURTH SEMESTER**					
CS601A6	Dissertation -Phase-I	0	0	30	15	CS602A6	Dissertation	0	0	50	25
		0	0	30	**15**			0	0	50	**25**
Total Contact Hours (L + T + P)		30				Total Contact Hours (L + T + P)		50			

Prof. (Dr.) Udit K Chakraborty, Chairperson, HoD CSE

Prof. (Dr.) Kalpana Sharma, Member, Dept. of CSE

Prof. (Dr.) C.T. Singh, Member, Dept of CSE

Prof. (Dr.) Biswaraj Sen, Member, Dept of CSE

Dr. Sandeep Gurung, Member, Dept of CSE

Dr. Nitai Paitya, Member, Dept of CSE

Mr. Santanu Kr. Misra, Member, Dept of CSE

Dr. Dhruba N, Member, Dept of CSE

Mr. Ashis Pradhan, Member, Dept of CSE

Ms. Nitisha Pradhan, Member, Dept of CSE

LIST OF ELECTIVE SUBJECTS- I SEMESTER					
SL. NO.	SUBJECT CODE	SUBJECT			
1	CS501A3	ADVANCED COMPUTER ARCHITECTURE	17	CS517A3	MACHINE LEARNING: THEORY AND METHODS
2	CS502A3	ADVANCED DATABASE SYSTEM	18	CS518A3	ADVANCED OPERATING SYSTEMS
3	CS503A3	BIOINFORMATICS	19	CS519A3	QUEUING THEORY AND MODELING
4	CS504A3	DIGITAL IMAGE PROCESSING	20	CS520A3	COMPUTER VISION
5	CS505A3	GRAPH THEORY FOR COMPUTER ENGINEERING APPLICATIONS	21	CS521A3	BLOCK CHAIN CODING
6	CS506A3	LINUX INTERNALS	22	CS522A3	CYBER SECURITY
7	CS507A3	REAL TIME SYSTEMS	23	CS523A3	COMMUNICATION SKILLS
8	CS508A3	REMOTE SENSING	24	CS524A3	SOCIAL NETWORK ANALYSIS
9	CS509A3	SYSTEM SIMULATION AND MODELING	25	CS525A3	PARALLEL AND DISTRIBUTED ALGORITHMS
10	CS510A3	ADVANCED COMPUTER NETWORKS	26	CS526A3	QUANTUM COMPUTING
11	CS511A3	ADVANCED SOFTWARE ENGINEERING	27	CS527A3	APPLICATIONS OF WEB TECHNOLOGY
12	CS5123A3	ADVANCED SOFT COMPUTING	28	CS528A3	PROGRAMMING IN JAVA
13	CS513A3	OBJECT ORIENTED ANALYSIS AND DESIGN USING UML	29	CS529A3	ARTIFICIAL NEURAL NETWORK & APPLICATIONS
14	CS514A3	ARTIFICIAL INTELLIGENCE	30	CS530A3	USER INTERFACE & USER EXPERIENCE
15	CS515A3	INTERNET OF THINGS			
16	CS516A3	INTELLECTUAL PROPERTY RIGHTS			

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Mr. Ashis Pradhan, Member, Dept of CSE

Ms. Nitisha Pradhan, Member, Dept of CSE

LIST OF ELECTIVE SUBJECTS- II SEMESTER					
SL. NO	SUBJECT CODE	SUBJECT	SL. NO	SUBJECT CODE	SUBJECT
1	CS530A3	ADVANCED CRYPTOGRAPHY AND NETWORK SECURITY	17	CS546A3	SPEECH AND NATURAL LANGUAGE PROCESSING
2	CS531A3	BIG DATA	18	CS547A3	DEEP LEARNING
3	CS532A3	AD HOC WIRELESS NETWORKS	19	CS548A3	DISTRIBUTED DATABASE SYSTEMS
4	CS533A3	CLOUD COMPUTING	20	CS549A3	MOBILE COMPUTING
5	CS534A3	DATA WAREHOUSING AND DATA MINING	21	CS550A3	HIGH PERFORMANCE COMPUTING
6	CS535A3	GEOGRAPHICAL INFORMATION SYSTEM	22	CS551A3	HUMAN COMPUTER INTERACTION
7	CS536A3	ENGINEERING RESEARCH METHODOLOGY	23	CS552A3	AGILE METHODOLOGY
8	CS537A3	MOBILE ROBOTICS AND INTELLIGENT SYSTEMS	24	CS553A3	SECURITY & ETHICAL HACKING
9	CS538A3	NETWORK SECURITY	25	CS554A3	SOFT SKILLS IN INDUSTRY
10	CS539A3	OPTIMIZATION TECHNIQUES	26	CS555A3	INTRODUCTION TO EMBEDDED SYSTEM
11	CS540A3	VLSI DESIGN	27	CS556A3	ADVANCED PYTHON PROGRAMMING
12	CS541A3	WIRELESS SENSOR NETWORKS	28	CS557A3	DESIGN THINKING FOR ENGINEERING
13	CS542A3	DATA ANALYTICS			
14	CS543A3	DISTRIBUTED SYSTEMS			
15	CS544A3	OBJECT ORIENTED SYSTEMS			
16	CS545A3	SOFTWARE QUALITY MANAGEMENT			

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Sub code: CS501A1 **Credit: 3 (L-2, T-1, P-0)**

Sub Name: ADVANCED ALGORITHMS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course introduces different techniques of designing and analysing algorithms. This will enable the learning about the framework for algorithm analysis, such as, low bound arguments, average case analysis, and the theory of NP-completeness. The learning outcome of this course will enable the learners to rigorously apply order metrics to computational problems, design an algorithm for a problem and analyse its resource complexity, distinguish between Branch-And-Bound and Backtracking and identify the possibility of intractability for a given problem.

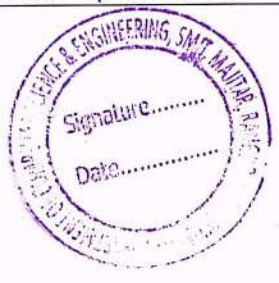
Pre-requisites: Data structures, Design and Analysis of Algorithms and Automata Theory.

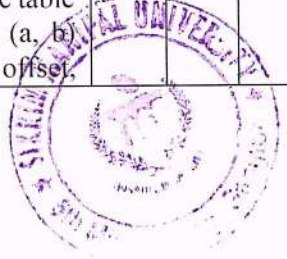
Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to

1. Compare different algorithmic design strategies.
2. Argue the correctness of algorithms using inductive proofs and invariants.
3. Analyse the complexity of a given algorithm.
4. Decide which algorithm and data structures among a set of possible choices are best for a given application.
5. Design efficient algorithms for new situations.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: < Review of basic concepts & Algorithm Design Paradigm >	in class	Review of basic concepts: Complexity measures, worst-case, average case and amortized complexity functions, model of computation. Algorithm Design Paradigm: Divide and Conquer, Recursion, Greedy method, Dynamic programming. Role of Data Structures	8	1		
	**Assignment Topics					
Module 2: < Sorting and Selection Problems &. Searching and Selection Problems >	in class	Sorting and Selection Problems: Order Statistics, sorting methods, lower bounds. Searching and Selection Problems: Order Statistics, searching methods, lower bounds.	7	1,2		
	**Assignment Topics					
Module 3: < Searching and Set manipulation >	in class	Searching and Set manipulation: Searching in Static table - path lengths in Binary trees and applications, optimality of Binary search in worst case and average case, construction of weighted Binary Search tree. Searching in dynamic table - randomly grown binary search trees, AVL trees, (a, b) trees; Union-find problem-tree representation offset,	8	3		





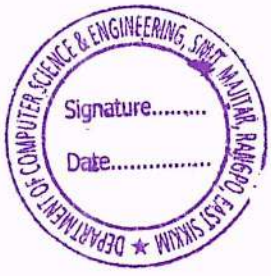
		weighted union and path compression, analysis and application.				
	**Assignment Topics					
Module 4: <Hashing & Graph algorithms>	in class	Hashing: Chaining, open addressing, universal hashing function. Graph algorithms: Review of topological sort, connected and bi-connected components, shortest paths, minimum spanning trees. Maximum matching, maximum-flow (Ford-Fulkerson).	9	4,5		
	**Assignment Topics					
Module 5: < Arithmetic and Algebraic problems & NP-completeness >	in class	Arithmetic and Algebraic problems: Integer multiplication, GCD, Polynomial evaluation, Matrix Multiplication, Lower Bounds. Introductory String ology. Some geometric algorithms. NP-completeness: Determinism and non-determinism, P, NP, NP-complete, Cook's theorem, Some NP-complete problems, Approximation algorithms. Notion of Randomization and Parallelism in algorithms.	8	5		
	**Assignment Topics					

Text Books:

1. V. Aho, J. E. Hopcroft and J. D. Ullman: Design and Analysis of Algorithms, Addison- Wesley.
2. T. H. Cormen, C. E. Leiserson and R. L. Rivest: Introduction to Algorithms, MIT Press.

Reference Books:

3. U. Manber: Introduction to Algorithms, Addison-Wesley.
4. G. Brassard and P. Bartley: Algorithmics: Theory and Practice, Prentice Hall International



ELECTIVE I

CS5**A3 **Credit 3(L-03, T-0,P-0)**

No. of questions to be set: 05 (FIVE)

No. of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES

ELECTIVE II

CS5**A3 **Credit 3(L-03, T-0,P-0)**

No.of questions to be set: 05 (FIVE)

No.of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES

ELECTIVE III

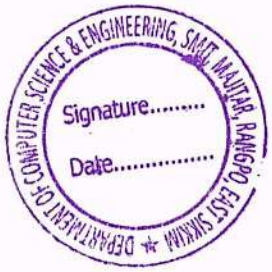
CS5**A3 **Credit 3(L-03, T-0,P-0)**

No.of questions to be set: 05 (FIVE)

No.of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES



ELECTIVE IV

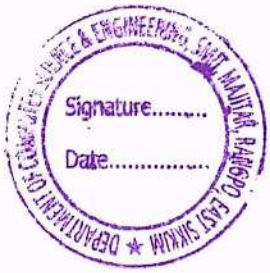
CS5**A3 **Credit 3(L-03, T-0,P-0)**

No.of questions to be set: 05 (FIVE)

No.of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES



CS501A4 **Credit: 1.5 (L-0,T-0,P-3)**

MACHINE LEARNING LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CS 2149 Machine Learning: Theory and Methods and associated prerequisites.

CS502A4 **Credit: 1.5 (L-0,T-0,P-3)**

ADVANCED ALGORITHMS LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CS2104 - Advanced Algorithm and associated prerequisites.

CS501A5 **Credit: 2 (L-0,T-0,P-4)**

PROJECT BASED LEARNING- I

Small project will be done as a part of the course work and will be evaluated through presentation.

Sub Code: CS502A1 **Credit: 3(L-2, T-1, P-0)**

Sub Name: THEORY OF COMPUTATION

Questions to be set: 05 (All Compulsory)

Course Objectives: This course presents formal models for the computation of functions and for the recognition and generation of languages. The central goal is to define the four language classes in the Chomsky hierarchy in terms of grammars that generate each class and in terms of automata that recognize each class. By the end of the course, the learners will have a clear vision on computational models and computability.

Pre-requisites: Formal Language and Automata theory.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Explain the basic concepts of finite automata and regular expressions
2. Describe the types of grammar and derivation tree
3. Test the equivalence of pushdown automata and CFL
4. Develop a computational model using Turing machine for the given problem
5. Examine the complexity for P and NP completeness for the given problem

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction to Finite Automata >	in class	Introduction to Finite Automata: Alphabets and languages, Finite Representation of Languages, Deterministic Finite Automata, Non- deterministic Finite Automata, Equivalence of Deterministic and Non-Finite Automata, Properties of the Languages Accepted by Finite Automata, Finite Automata and Regular Expressions, Proof of Regular and non- Regular Languages (Pumping Lemma)	9	1		
	**Assignment Topics					
Module 2: < Context Free Languages >	in class	Context Free Languages: Context –Free Grammar, Regular Languages and Context-Free Grammar, Pushdown Automata, Pushdown Automata and Context-Free Grammar, Properties of Context-Free Languages, Closure Properties, Periodicity Properties, Determinism and Parsing, Deterministic Pushdown Automata and Context Free Languages, Top- down Parsing, Bottom – Up parsing	6	1,2		
	**Assignment Topics					
Module 3:	in class	Turing Machines: The Definition of Turing Machine, Church-Turing Thesis, Computing with Turing Machines,	8	3		

< Turing Machines >		Combining Turing Machines, Primitive Recursive Functions, Computability of μ-Recursive Functions, Universal Turing Machine, Closure Properties of RE and R sets, Undesirability, Reductions, RE Completeness, Non-RE languages, Rice Theorem.				
	**Assignment Topics					
Module 4: < Un-computability & Computational Complexity >	in class	Un-computability: Turing Machine Halting Problem, Turing Decidability, Turing Acceptability, Post Correspondence Problem. Computational Complexity: Time Bounded Turing Machine, Rate of Growth of Functions, Classes P and NP, Some NP Complete Problems, Time and Space Complexity Classes, Hierarch Theorems, Savitch's Theorem, Immerman Szelepscenyi Theorem.	9	4		
	**Assignment Topics					
Module 5: < Prepositional Calculus & Predicate Calculus >	in class	Prepositional Calculus: Propositional calculus and Predicate Calculus, Satisfiability and validity, Notions of soundness and completeness. Predicate Calculus: Syntax of Predicate Calculus, Structures and Satisfiability, Equivalence, Unsolvability, Resolution in Predicate Calculus.	8	4,5		
	**Assignment Topics					

Text Books:

1. Automata and Computability, Dexter C. Kozen, Springer
2. Introduction to Automata Theory, Languages and Computation, John E. Hopcroft, Rajeev Motwani, Jeffrey D Ullman, Pearson

Reference Books:

1. Introduction to Computability, Fredrick C Hennie, Addison- Wesley
2. Automata Theory and its Applications, Bakhadyr Khoussainov, Anil Nerode, Springer
3. Discrete Mathematical Structures with Applications to Computer Science, J.P. Trembley, R. Manohar, TATA McGraw Hill.
4. Introduction to Languages and the Theory of Computation, John C. Martin, TATA McGraw Hill.

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING, SMIT, MAJITAR, RANGPO, EAST SIKKIM ★ Signature..... Date.....

ELECTIVE V

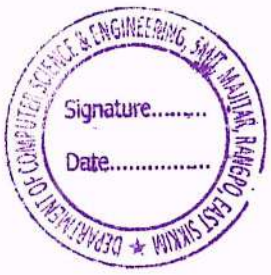
CS5**A3 **Credit 3(L-03, T-0,P-0)**

No.of questions to be set: 05 (FIVE)

No.of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES



ELECTIVE VI

CS5A3** **Credit 3(L-03, T-0, P-0)**

No. of questions to be set: 05 (FIVE)

No. of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

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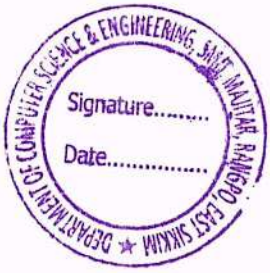

ELECTIVE VII

CS5**A3 **Credit 3(L-03, T-0,P-0)**

No. of questions to be set: 05 (FIVE)

No. of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

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ELECTIVE VIII

CS5**A3 **Credit 3(L-03, T-0,P-0)**

No. of questions to be set: 05 (FIVE)

No. of questions to be answered: FIVE (Compulsory)

Objectives and Pre-requisites are given under Detailed Elective syllabi.

TO BE CHOSEN/OFFERED FROM POOLED ELECTIVES

SIKKIM MANIPAL UNIVERSITY

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING, SMIT, MAJITAR, RANGPO, EAST SIKKIM

Signature.....

Date.....

CS503A4 **Credit 1.5(L-0, T-0,P-03)**

ADVANCED PROGRAMMING LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper and associated prerequisites.

CS504A4 **Credit 1.5(L-0, T-0,P-03)**

SOFTWARE AND DATA ANALYSIS LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper and associated prerequisites.

CS502A5 **Credit 2(L-0, T-0,P-04)**

PROJECT BASED LEARNING-II

Small project will be done as a part of the course work and will be evaluated through presentation.

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Signature.....
Date.....

CS601A6 **Credit 15(L-0, T-0,P-30)**

DISSERTATION (PHASE-I)

The students are required to undertake innovative and research oriented projects, not only to reflect their knowledge gained in the previous two (four for part time students) semesters but also to acquire additional knowledge and skill of their own effort. During their major project, the students are required to submit progress of their work in phases to make the department aware of his/her project. At the end of two semesters, students have to report to the internal guides/faculty members for final refinement and documentation.

It is mandatory to follow the software engineering methodologies in carrying out the project work. The project is evaluated through internal presentation before the panel of faculty members followed by the evaluation by an external examiner appointed by the university.

CS602A6 **Credit 25(L-0, T-0,P-50)**

DISSERTATION

The students are required to undertake innovative and research oriented projects, not only to reflect their knowledge gained in the previous two (four for part time students) semesters but also to acquire additional knowledge and skill of their own effort. During their major project, the students are required to submit progress of their work in phases to make the department aware of his/her project. At the end of two semesters, students have to report to the internal guides/faculty members for final refinement and documentation.

It is mandatory to follow the software engineering methodologies in carrying out the project work. The project is evaluated through internal presentation before the panel of faculty members followed by the evaluation by an external examiner appointed by the university.

Sub Code: CS501A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED COMPUTER ARCHITECTURE

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to learn the advanced aspects of computer architecture design. The course focuses on processor design, pipelining, superscalar, out-of-order execution, caches (memory hierarchies), virtual memory, storage systems, and simulation techniques. It also highlights the survey of parallel architectures and future directions in this field.

Pre-requisites: Computer Organization & Architecture and Concepts of Algorithm.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to

1. Identify the advanced concepts of computer architecture.
2. Identify the major differentials of RISC and CISC architectural characteristics.
3. Investigate modern design structures of Pipelined and Multiprocessors systems.
4. Correlate recent computer architectures and I/O devices, as well as the low-level language required to drive/manage these types of advanced hardware.
5. Formulate research statements in Computer Architecture.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: < Pipelined Architecture >	in class	Pipelined Architecture: Brief Introduction, Performance Measures - speed up, efficiency, performance - cost ratio etc. Static pipelines - reservation tables, scheduling of static pipelines, definitions - minimum average latency, minimum achievable latency, greedy strategy etc. Theoretical results on latency bounds with proof, Hardware intra-pipeline controller and scheduler, Theoretical results on Reservation Table optimization to support given latency cycle - actual case study.	6	1,2		
	****Assignment Topics**					
Module 2: < Dynamic pipelines & Instruction pipelines >	in class	Dynamic pipelines: Reservation tables, optimal scheduling strategy, Theoretical results on scheduling and reservation table optimization, hardware scheduler/controller design, Vector Processing - use of pipelines, detailed case study. Instruction pipelines: Performance measures. SIMD Architectures - brief introduction, various concepts illustrated by studying detailed SIMD algorithms, viz. Matrix multiplication, sorting on linear array, Mesh and Hypercube.	11	2		

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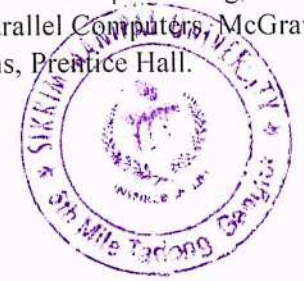
	**Assignment Topics					
Module 3: < Detailed study of Interconnection Network & Introduction to Parallel Processing >	in class	Detailed study of Interconnection Network: Boolean cube, Mesh, Shuffle-exchange, Banyan, Omega, Butterfly, Generalized Hypercube, Delta etc. - illustration of use in actual SIMD algorithms. Introduction to Parallel Processing: Criteria for judging the architecture, Architectural classification schemes, Trends towards parallel processing, Parallelism in uniprocessor systems, Parallel Computer Structure, Applications of parallel processing	11	3,4		
	**Assignment Topics					
Module 4: < MIMD Architectures >	in class	MIMD Architectures: Brief introduction, Classification LCS, TCS, Case study actual systems of both types. Synchronization primitives& possible hardware implementation, Memory access contention - reasons, Cache coherence problem - Solution and detailed implementation, MIMD algorithms & detailed implementation, viz. Matrix multiplication & Searching.	7	4		
	**Assignment Topics					
Module 5: < Systolic Architecture & Dataflow Architectures >	in class	Systolic Architecture: Detailed introduction, Kung's method - detailed illustration by an actual algorithm example, possible implementation using Transputer. Dataflow Architectures: Detailed study, Classification, Implementation (Dennis &Arvind), detailed case study with actual algorithms, extension of architecture to accommodate non-primitive data types.	5	5		
	**Assignment Topics					

Text Books:

1. P. M. Kogge: Architecture of Pipelined Computers, McGraw Hill
2. K. Hwang: Computer Arithmetic - Principles, Architecture and Design, John Wiley.

Reference Books:

1. Hwang & Briggs: Advanced Computer Architecture and Parallel processing, McGraw Hill.
2. Michael J Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw Hill.
3. S. G. Akl: The Design & Analysis of Parallel Algorithms, Prentice Hall.



4. K. Hwang & D. Degront: Parallel processing for Super Computers & Artificial Intelligence, McGrawHill.

Sub Code: CS502A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED DATABASE SYSTEM

Questions to be set: 05 (All Compulsory)

Course Objectives: This course aims in comparing and contrasting the emerging architectures for database management systems and understand the manner in which relational systems are implemented and their implications of the techniques of implementation on database performance.

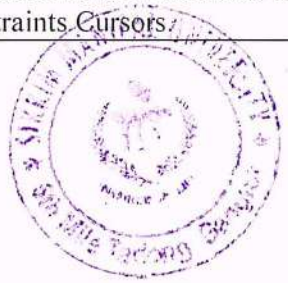
Pre-requisites: Data Structure, Database Management System and Programming concepts.

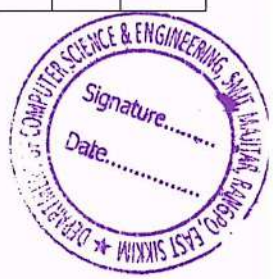
Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Enumerate the fundamental theories that influence the design of modern database systems
2. Assess and apply database functions and packages suitable for enterprise database development and database management
3. Critically evaluate alternative designs and architectures for databases and data warehouses
4. Analyse database requirements and determine suitable methods to implement these
5. Evaluate methods of storing and interrogating complex data

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction >	in class	Basics of database systems, Traditional file processing approach, Motivation for database approach, Evolution of database systems, Data Elements and Fields, Representing Relational Database Elements, Client-Server Systems, Logical and Structured Addresses, Data-definition language commands, Overview of query processing, Storage and buffer management, Transaction processing, The Entity-Relationship diagrams	5	1,2		
	****Assignment Topics**					
Module 2: < Relational Algebra and SQL >	in class	Relational Algebra: Basics of Relational Algebra, Operations on Relations, Extended Operators of Relational Algebra, Use of SQL, DDL Statements, DML Statements, View Definitions, Constraints and Triggers Keys and Foreign Keys, Constraints on Attributes and Tuples, Modification of Constraints Cursors	8	2		



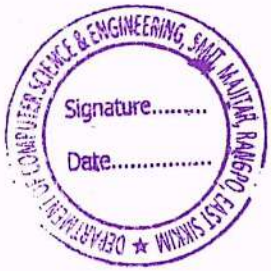


	**Assignment Topics					
Module 3: < Normalization >	in class	Normalization and its importance, First Normal form, Second Normal Form, Third Normal Form, Boyce- Codd Normal Form.	6	3		
	**Assignment Topics					
Module 4: < Transaction Management and Concurrency Control & Distributed Database >	in class	Transaction Management and Concurrency Control: Introduction to Transaction management, Serializability, Enforcing Serializability by Locks, Managing Hierarchies of Database Elements, Concurrency Control, Resolving Deadlocks Distributed Database : Homogeneous And Heterogeneous Database, Distributed Data Storage, Distributed Transaction, Commit Protocols, Concurrency Control In Distributed Databases, Availability, Heterogeneous.	11	4		
	**Assignment Topics					
Module 5: < Object–Oriented Databases & Enhanced Data Models for Advanced Applications >	in class	Object–Oriented Databases: Overview of object–oriented concepts, Object identity, Object structure and type, constructors, Encapsulation of operations, Methods and persistence, Type hierarchies and inheritance, Type extents and persistent programming languages, OODBMS architecture and storage issues. Enhanced Data Models for Advanced Applications: Active database concepts, temporal database concepts, spatial databases: concept and architecture, Deductive databases and query processing, Mobile databases.	10	4,5		
	**Assignment Topics					

Text Books:

1. Silberschatz, Korth, Sudarshan, Database System Concepts, McGraw-Hill Higher Education.
2. Ehmasri and Navathe: Fundamentals of Database Systems, Addison Wesley.
3. Bindu R. Rao: Object Oriented Databases, McGraw Hill.
4. S. Khoshafian& A. B. Baker, Multimedia and Imaging Databases, Morgan Kaufmann Publishers.
5. Alex Berson: Client/Server Architecture, McGraw Hill.

Reference Books:



1. Thomas Connolly, Carolyn Begg, Database Systems – A Practical Approach to Design,Implementation, and Management, Pearson Education.
2. JefreyD.Ulman, Jenifer Widom, A First Course in Database Systems, Pearson Education Asia.
3. Bipin C Desai, An Introduction to Database Systems, Galgotia Publications Pvt Limited.
4. AtulKahate, Introduction to Database Management systems, Pearson.
5. Kemper &Moerkoette: Object-Oriented Database Management, Prentice Hall.

Sub Code: CS503A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: BIOINFORMATICS

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is designed to introduce the basic concepts, methods, and tools used in Bioinformatics. Topics include (but not limited to) bioinformatics databases, sequence and structure alignment, protein structure prediction, protein folding, protein-protein interaction, Monte Carlo simulation, and molecular dynamics. Emphasis will be put on the understanding and utilization of these concepts and algorithms. The objective is to help the students to reach rapidly the frontier of bioinformatics and working knowledge of a variety of publicly available data and the bioinformatics tools in handling flood of biological data and to solve the problems on their own research.

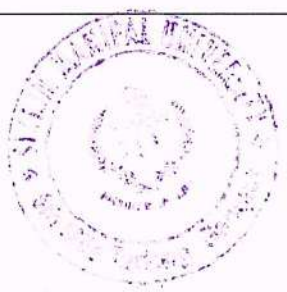
Pre-requisites: Concept of Algorithms, Probability and Statistics and Knowledge of Biology.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Identify the underlying principles of bioinformatics.
2. Choose suitable computational models to solve the problem for a given biological sequence analysis problem
3. Interpret the advantages and/or disadvantages of these approaches
4. Identify research topics in bioinformatics
5. Modify existing solutions and methods to suit a given problem

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: < Overview >	in class	Definition and History, Information Networks, Internet in Bioinformatics, EMBnet, Commercial Databases and Softwares, Intranet and Internet Packages, Bioinformatics Glossary.	4	1,2		
	**Assignment Topics					



Module 2: < Protein Information Resources >	in class	Biological Databases, Primary Sequence Databases, Composite Protein Sequence Databases, - Secondary Databases, Prosite, Prints, Blocks Profiles and Identity.	6	2		
	**Assignment Topics					
Module 3: < Probability and Statistics >	in class	Measures of Central tendency and dispersions: Arithmetic Mean, Median, Mode, Quartiles, Range, Quartile deviation, Mean deviation, Standard Deviation, Probability: Definitions, Addition Theorem, Multiplication Theorem, Baye's Theorem and related problems, Theoretical Distributions: Binomial, Poisson and Normal, Goodness of fit: Fitting of the Distributions and its properties, Z score, P value and E value	10	2,3		
	**Assignment Topics					
Module 4: < Physiochemical Properties & Commercial Bioinformatics >	in class	Physiochemical Properties: Introduction and Physiochemical Properties of Nucleic Acids, DNA and RNA. Watson and Crick Model of DNA and the different forms of DNA. RNA structure, Principles and Prediction. Gene Structure. Commercial Bioinformatics: Definition of Bioinformatics Company, Genome Technology; high throughput sequencing and assembly.	10	4		
	**Assignment Topics					
Module 5: < Microarrays and genome wide expression analysis >	in class	Transcriptome, proteome, Genomics in medicine, diseases monitoring, profiles for therapeutic molecular targeting., Sequences, protein and DNA, Multiple Sequence Alignment, Concepts,((Clustal W, ClustalX, PILE UP), Algorithms, MSA, Progressive alignment etc., Problems with MSA method, Statistics behind MSA	10	4,5		
	**Assignment Topics					

Text Books:

1. Arthur M. Lesk, "Introduction to Bioinformatics", Oxford University Press, New Delhi.
2. T.K. Attwood and D.J. Parry-Smith, "Introduction to Bioinformatics", Pearson Education Ltd., NewDelhi.
3. S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, NewDelhi.
4. David W. Mount, Bioinformatics: Sequence and Genome Analysis.

Reference Books:

1. D. Higgins and W. Taylor (Eds), "Bioinformatics- Sequence, structure and databanks", OxfordUniversity Press, New Delhi.
2. Baxevanisand B.F. Ouellette, " Bioinformatics: A practical Guide to the Analysis of Genes andProteins", Wiley-Interscience, Hoboken, NJ.
3. S. R. Swindell, R.R.Miller and G.S.A.Myers (Eds.), "Internet for the Molecular Biologist", HorizonScientific Press, Wymondham, UK,.

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4. Andrea Cabibbo, Richard Grant and Manuela Helmer-Citterich (Eds.), "The Internet for Cell andMolecular Biologists (2nd Edn.)", Horizon scientific Press, Norwich, UK .
5. Kemper &Moerkoette,"Object-Oriented Database Management", Prentice Hall.

Sub Code: CS504A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: DIGITAL IMAGE PROCESSING

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to provide the students a general understanding of the fundamentals of digital image processing. It also introduces analytical tools which are currently used in digital image processing. By the end of the course student will be able to develop any software/programs that uses image restoration, enhancement and compression etc.

Pre-requisites: Computer Graphics, Engineering Mathematics and Probability & Statistics

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Describe the methods presented in the course as far as both the mathematical analysis and the applications related to each method are concerned.
2. Apply the methods presented or combinations of them, or modifications of them in a real life image processing problem.
3. Decide which method is appropriate to tackle a real life problem
4. Identify research areas in Digital Image Processing.
5. Plan future research in the field of Digital Image Processing.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1:	in class	Digital image representation, Fundamental steps in Image Processing, Elements of DIP systems	5	1		

< Introduction >	**Assignment Topics					
Module 2: < Digital Image Fundamentals & Image Enhancement in Spatial domain>	in class	Digital Image Fundamentals: Elements of Visual Perception, Sampling and Quantization, Relationships between pixels, Linear and Nonlinear operations. Image Enhancement in Spatial domain: Enhancement by Point Processing, Histogram Processing, Spatial Filtering.	10	2,3		
	**Assignment Topics					
Module 3: < Image Enhancement in Frequency Domain & Image Compression >	in class	Introduction to the Fourier Transform, The discrete Fourier Transform, Properties of the two- dimensional Fourier Transform, Smoothing Frequency-domain filters, Sharpening Frequency domain filters. Image Compression: Fundamentals, Image Compression Models, Error Free Compression, Lossy Compression	10	3		
	**Assignment Topics					
Module 4: < Image Segmentation & Representation and Description >	in class	Threshold Techniques: Global, Adaptive and Optimum thresholding, Edge detection, Region Growing. Representation and Description: Representation Schemes, Boundary Descriptors, Regional Descriptors.	10	4		
	**Assignment Topics					
Module 5: < Object Recognition >	in class	Patterns and Pattern Classes, Recognition based on Decision-theoretic methods, structural methods.	5	4,5		
	**Assignment Topics					

Text Books:

1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", Pearson.
2. RajjanShinghal, "Pattern Recognition", Oxford Publications.

Reference Books:

1. Chanda and Majumder, "Digital Image Processing and Analysis", Prentice Hall Publications.
2. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing with Matlab", Pearson.
3. S. Sridhar, "Digital Image Processing", Oxford University Press.
4. Jayaraman, "Digital Image Processing", McGraw Hill.

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Sub Code: CS505A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: GRAPH THEORY FOR COMPUTER ENGINEERING APPLICATIONS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides a detailed theory and applications of various types and classes of graphs. Topics include Graphs, Sub graphs, path, walk, circuits, cut sets, tournaments, connectivity, trees, Eulerian graphs, Hamiltonian graphs, planarity, graph colourings, matching, and domination, independence, directed graphs, networks and applications in computer engineering.

Pre-requisites: Basic graph theory and graph algorithms, Basic mathematics and Programming concepts.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define the basic concepts of graphs, directed graphs, weighted graphs and bipartite graphs, Eulerian, Hamitonian and plane graphs.
2. Find the components of a graph and the strongly connected components of a digraph.
3. Apply coloring algorithms to color a given graph or to find its chromatic polynomial.
4. Construct breadth/depth first search and minimum weight spanning tree of a connected graph.
5. Perform advanced operations on a graph.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction & Tree>	in class	Introduction: Definitions, applications of graph in Diagram tracing, Konigsberg bridge problem, Chinese postman problem, DNA fragment assembly, floor design, Knight's tour, Integer programming, Solution to the travelling salesman problem. Isomorphism, walks, paths, circuits, connected, disconnected, graphs, operations in graphs-Euler & Hamilton graphs. Tree: Properties, distance & centres, binary trees, fundamental circuits, minimal spanning tree. Tree traversal. Applications of Tree in manipulating hierarchical data, Parse tree, File system, manipulate sorted lists of data, workflow for compositing digital images for visual effects and Routing algorithms.	6	1		
	****Assignment Topics**					
Module 2: < Cut Sets & Planar and Dual Graphs >	in class	Cut Sets: Properties, Fundamental circuits and cut sets, connectivity, separatability network flows, 1-2 isomorphism. Applications of cut sets to solve graph models for reliability analysis,	7	2		

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		identify potential single point failures in a modelled system, state equation for network and superposition network theorem. Planar and Dual Graphs: Combinational representation, planar graphs, Kuratowshi's graphs detection of planarity, dual graphs. Applications of planar graphs in image segmentation, shape matching, extended modelling capabilities, route planning.				
	**Assignment Topics					
Module 3: < Matrix Representation of Graph & Vector Spaces Of A Graph>	in class	Matrix Representation of Graph: Incidence matrix, circuit matrix, cut set matrix, fundamental matrices, relationships among matrices, path matrix, and adjacency matrix. Applications of Matrix in computer programming language for the computation of path or circuit. Vector Spaces Of A Graph: Sets with One Operation, Sets with Two Operations, Modular Arithmetic and Galois fields,Vectors and Vectors Spaces, Vector spaces Associated with a Graphs, Basis vectors of a Graph, Circuit and Cut-Set Subspaces , Orthogonal Vectors and Spaces, Intersection and join of W and Ws,.	11	2,3		
	**Assignment Topics					
Module 4: < Coloring, Covering, Partitioning & Directed Graphs>	in class	Coloring, Covering & Partitioning: Chromatic number, chromatic partitioning, matching, covering, four color problem. Coloring and covering concepts used in pattern matching, register allocation, frequency assignment in GSM, timetabling, scheduling and computer network security. Directed Graphs: Different types, directed path, and connectedness, Euler digraphs, Trees, matrix representation, tournament. Directed graphs used in compiler construction, finite state machine, combinational circuit design and traffic flow problem.	9	3,4		
	**Assignment Topics					
Module 5: < Enumerations Of Graphs , Graph Theoretic Algorithms and Applications>	in class	Enumerations Of Graphs: Types of Enumeration, counting labeled Trees, Counting Unlabeled Trees, Polya's Counting Theorem, Graph Enumeration with Polya's Theorem. Graph Theoretic Algorithms: Computer representation of graphs, Input / output. Devising algorithms for connectedness, a spanning tree, fundamental circuits, cut vertices, directed circuits, shortest paths. Applications of Graph theoretic algorithm in worm propagation, workflow for compositing digital images for visual effects, routing algorithms. Applications: Graph in sequential switching networks, graph in coding theory, graph in signal flow graph, graph inmarkov process, and graphics in computer	7	5		

		programming. Applications in code generation, sequential switching networks, graphics.				
	**Assignment Topics					

Text Books:

1. N.Deo, Graph Theory with applications to Engineering and Computer Science, Prentice Hall of India
2. Jonathan L. Gross and Jay Yellen, Graph Theory and Its Applications

Reference Books:

1. Tulasiraman& MNS Swamy, Graphs, Networks & Algorithms, Mily,
2. F. Harary, Graph Theory, Addison Wessly
3. Jonathan L. Gross and Jay Yellen , Handbook of Graph Theory,
4. Jonathan L. Gross and Thomas W. Tucker, Topological Graph Theory, Dover publications

Sub Code: CS506A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: LINUX INTERNALS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course covers in fine details various issues pertaining to memory addressing, processes, interrupts and exceptions, kernel synchronization, timing measurements, memory management etc. This course will enable the students to understand the functioning of Linux kernel.

Pre-requisites: Operating System.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Apply the "bash" shell and the basic commands in this shell.
2. Write scripts to be run with bash in Linux operating system.
3. Administer Linux operating systems.
4. Explain the concept of open source software development.
5. Develop independent modules for the Linux operating system.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction to Linux & Memory Addressing>	in class	Introduction: Linux versus other Unix-like kernels, Hardware Dependencies, Linux Versions, Basic OS Concepts, An overview of the Unix file system, An overview of the Unix Kernel. Memory Addressing: Memory Addresses, Segmentation in Hardware, segmentation in Linux, Paging in Hardware, paging in Linux.	6	1		
	**Assignment Topics					
Module 2: < Processes & Interrupts and Exceptions >	in class	Processes: Processes, Lightweight processes and threads, process Descriptor, Process Switch, Creating Processes, Destroying Processes. Interrupts and Exceptions: The role of Interrupt Signals, Interrupts and Exceptions, Nested Execution of Exceptions and Interrupt handlers, Initializing the Interrupt Descriptor Table, Exception Handling, Softirqs, Tasklets and Bottom Halves, Returning from Interrupts and Exceptions.	10	2		
	**Assignment Topics					
Module 3: < Kernel Synchronization >	in class	Kernel Synchronization: Kernel Control Paths, Conditions for Synchronization, Synchronization Primitives, Synchronizing Access to Kernel Data Structure Example of Race Condition Prevention.	7	3,4		
	**Assignment Topics					

Module 4: < Memory Management & Process Address Space >	in class	Memory Management: Page Frame Management, Memory Area Management, Noncontiguous Memory Area Management. Process Address Space: The Process Address Space, The Memory Descriptor, Memory Regions, Page Fault Exception Handler, Creating and Deleting a Process Address Space, Managing the Heap.	8	4,5		
	**Assignment Topics					
Module 5: < The Virtual File System & Swapping: Methods for Freeing Memory >	in class	The Virtual File System: The role of Virtual File system (VFS), VFS Data Structures, File system Types, File system Mounting, Pathname Lookup, Implementations of VFS System Calls, File Locking. Swapping: Methods for Freeing Memory:- Definition and concept of swapping, Swap Area, The Swap Cache, Transferring Swap Pages, Swapping Out Pages, Swapping in Pages, Reclaiming Page frame	9	5		
	**Assignment Topics					

Text Books:

1. Daniel P. Bovet & Marco Cesati : "Understanding the Linux Kernel", 2nd Ed., O'Reilly Publishers,2002.
2. W. Richard Stevens, "Advance Programming in Unix Environment", 14th Ed., Pearson Pte. Ltd., 2004

Reference Books:

1. Maurice J. Bach, "Design of the UNIX Operating System", 1st Ed., Pearson Pte. Ltd., 2004.
2. Jeffrey S. Horwitz, "Unix System Management Primer Plus", 1st Ed., Pearson Publishers, 2004.
3. UreshVahalia, "UNIX Internals: The new frontiers", 1st Ed., Pearson Publishers, 2005.
4. George Pajari, "Writing Unix device drivers", 1st Ed., Pearson Publishers, 2004.

Sub Code: CS507A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: REAL TIME SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to provide a general understanding of the Real time systems. It covers the scheduling aspects of tasks with emphasis on timing constraints and scheduling principles. By the end of the course, the students shall be able to differentiate the scheduling and communication aspects of Real Time Systems from those of traditional Operating systems.

Pre-requisites: Operating System, Computer Network

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define the concepts and recognize the characteristics of a real-time system.
2. Identify and implement important software engineering principles for real-time system development.
3. Produce an architectural design of a real-time system.
4. Evaluate the real-time systems in appropriate terminology and the real-time characteristics of a given system to assist in deciding which software or kernel is appropriate for a problem.
5. Interpret and contrast the design of a real-time system in a range of commonly understood formats

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction to RTS & Modeling time constraints >	in class	Introduction: Definition and concepts of RTS. Evolution of RTS. Examples of RTS, Broad categories of RT systems, Characteristics of RT systems, RT tasks classification, Basic RTOS concepts, Examples. Modeling time constraints : Modeling of time constraints, Events in a RTS, Classification of timing constraints, Various types of RTS Modeling.	7	1		
	**Assignment Topics					
Module 2: < RT task scheduling >	in class	Basics on RT task scheduling, RT task scheduling algorithms (clock based, priority based), Pre- emptive RT algorithms (Earliest deadline first, RMA), Issues associated with RMA, Issues in using RMA in practical situations, Static priority scheduling protocols, Resource sharing among RT Tasks, Priority inversion, Priority inheritance protocol (PIP), HLP, PCP, Different types of priority inversion under PCP, Issues in using a resource sharing protocol, Handling task dependencies.	12	2		
	**Assignment Topics					
Module 3: < Scheduling RT tasks in multiprocessor	in class	Scheduling RT tasks in multiprocessor and distributed systems: Multiprocessor task allocation, Dynamic allocation of tasks, Fault tolerant scheduling of tasks, Clocks in distributed RTS, Clock synchronization.	5	3		

and distributed systems >	**Assignment Topics					
Module 4: < Commercial RTOS & Performance benchmarking of RTOS >	in class	Commercial RTOS: Characteristics, Examples, UNIX V as RTOS, UNIX based RTOS with examples, Introduction to RT POSIX, RT capabilities of windows NT, Brief introduction to windows CE. Performance benchmarking of RTOS: Various Benchmark Parameters.	7	3,4		
	**Assignment Topics					
Module 5: < RT communication & Real time databases >	in class	RT communication: Characteristics of RT traffic, Models for traffic characterization, Applications requiring RT communication, Soft and hard RT communication in a LAN, Bounded access protocols for LANs, Performance comparison, QoS framework, Routing, Rate control, QoS models. Real time databases : Applications of RT databases, Real time databases, Characteristics of temporal data, Concurrency control in RT databases, Commercial RT databases.	9	5		
	**Assignment Topics					

Text Books:

1. Rajiv Mall, Real Time Systems, Theory and Practice, Pearson Education.
2. J.W. Liu, Real Time systems, Pearson Education.

Reference Books:

1. Phillip Laplante, Real Time Systems Design and Analysis, Prentice Hall.
2. Krishna & Shin, Real Time systems, Tata McGraw Hill
3. Mark H. Klein, Thomas Ralya,Practitioner's Handbook for Real-Time Analysis, Kluwers Academic Publishers
4. Hassan Gomaa, Software Design Methods for Concurrent and Real-time Systems, Addison- Wesley

Sub Code: CS508A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: REMOTE SENSING

Questions to be set: 05 (All Compulsory)

Course Objectives: Introduce the principles of remote sensing to students who are beginners in this field. Much as the text book has laid out, fundamental knowledge on the physics of remote sensing, aerial photographic techniques, photogrammetric, multispectral, hyper-spectral, and thermal imaging, and RADAR and LIDAR image analysis will be introduced. The newest technology in the field will also be discussed. The subject will be synthesized by developing an overall application of the discipline, not just knowledge in one aspect. The course will be taught with an emphasis on the geographical applications of remote sensing. Lab assignments will supplement classroom discussion and reading assignments. At the end of the semester students should have a good understanding and basic skills of remote sensing.

Pre-requisites: Real Time System, Digital Image Processing

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define the concepts and recognize the characteristics of a real-time system.
2. Identify and implement important software engineering principles for real-time system development.
3. Produce an architectural design of a real-time system.
4. Evaluate the real-time systems in appropriate terminology and the real-time characteristics of a given system to assist in deciding which software or kernel is appropriate for a problem.
5. Interpret and contrast the design of a real-time system in a range of commonly understood formats

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Physics of Remote Sensing >	in class	Introduction of Remote Sensing- Electromagnetic spectrum, physics of remote sensing-Effects of atmosphere- scattering- Different types- Absorption- Atmospheric Window- Energy interaction with surface features- Spectral Reflectance of vegetation, soil and water- atmospheric influence on spectral response patterns- multi concept in Remote Sensing.	5	1		
	**Assignment Topics					
Module 2: < Data Acquisition >	in class	Data Acquisition: Types of platforms- Different types aircraft- Manned and Unmanned space crafts – sun synchronous and geo synchronous satellites- Types and characteristics of different platforms – LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICKBIRD, etc. – Photographic products, B/W, colour, colour IR film and their characteristics – resolving power of lens and film – Opto mechanical electro optical sensors – across track and along track scanners – multi spectral scanners and	7	2,3		

		thermal scanners – geometric characteristics of scanner imagery – calibration of				
	****Assignment Topics**					
Module 3: < Scattering System >	in class	Microwave scatterometry – types of RADAR – SLAR – resolution – range and azimuth – real aperture and synthetic aperture RADAR. Characteristics of Microwave images- topographic effect – different types of Remote Sensing platforms –air borne and space borne sensors – ERS, JERS, RADARSAT, RISAT – Scatterometer, Alimeter- LiDAR Remote Sensing, principles, applications	7	3,4		
	****Assignment Topics**					
Module 4: < Multi Spectral & Hyper Spectral Remote Sensing and Thermal Radiation Principles and Thermal Imaging >	in class	Multi Spectral & Hyper Spectral Remote Sensing: Sensors characteristics – principle of spectroscopy – imagine spectroscopy – field conditions, compound spectral curve, Spectral library, radiative models, processing procedures, derivative spectrometry, thermal remote sensing – thermal sensors, principles, thermal data processing, applications. Thermal Radiation Principles and Thermal Imaging: Thermal remote sensing– thermal sensors, principles, thermal data processing, applications	9	4		
	****Assignment Topics**					
Module 5: < Data analysis & Applications of remote sensing: >	in class	Data analysis: resolution- spatial, spectral, radiometric and temporal resolution- signal to noise ratio- data products and their characteristics – visual and digital interpretation –basic principles of data processing – radiometric correction –image enhancement –image classification – principles of lidar, aerial laser terrain mapping. Applications of remote sensing: Remote sensing of soils and geomorphology, Remote Sensing of vegetation, Remote sensing of water resources and Urban applications using remote sensing imagery.	12	4,5		
	****Assignment Topics**					

Text Books:

1. Jensen, John R., 2000, Remote Sensing of the Environment: An Earth Resource Perspective, New Jersey: Prentice Hall, 544 pages. ISBN 0-13-489733-1.

Reference

1. Lillsand T.M. and Keifer, R.W. Remote sensing and Image Interpretation, VI edition of John Wiley & Sons-2000.
2. John R. Jesen, Introductory Digital Image Processing: A Remote Sensing Perspective, 2nd Edition, 1995.
3. John A.Richards, Springer-Verlag, Remate Sensing Digital Image Analysis 1999.

4. Paul Curran P.J. Principles of Remote Sensing, ELBS, 1995.
5. Charles Elachi and JakobJ.vanZyl, Introduction to the Physics and Techniques of Remote Sensing, Wiley Series in Remote Sensing and Image Processing, 2006.
6. Sabins, F.F.Jr, Remote Sensing Principles and Image Interpretation, W.H. Freeman &co, 1978.

Sub Code: CS509A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: SYSTEM SIMULATION AND MODELING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course envisages the fundamentals of discrete event simulation (DES), which includes discrete event simulation methodology, development of simulation models, verification and validation, and the design of simulation experiments.

Pre-requisites: Probability & Statistics and System Analysis concepts.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define basic concepts in modeling and simulation and demonstrate an understanding of system modeling through the competent use of computer simulation methods and mathematical modeling techniques.
2. Determine the type of systems whose behaviour can be investigated using discrete event simulation and modeling as well as system dynamics-simulation modeling technique.
3. Classify various simulation models and give practical examples for each category.
4. Construct a model for a given set of data and motivate its validity.
5. Generate and test random number variates and apply them to develop simulation models

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Simulation Basics >	in class	Components of a system, Model of a system, Types of models, Discrete versus Continuous Modeling, steps in simulation study, Advantages, Disadvantages, and pitfalls of simulation, Handling Stepped and Event-based Time in Simulations, Numerical Techniques, Sources and Propagation of Error.	9	1,2		
	**Assignment Topics					
Module 2: < Dynamical, Finite State and Complex Model Simulations >	in class	Dynamical, Finite State and Complex Model Simulations: Graph or Network Transitions Based Simulations, Actor Based Simulations, Mesh Based Simulations, Hybrid Simulations.	6	2,3		
	**Assignment Topics					
Module 3: < Converting to Parallel and Distributed Simulations >	in class	Partitioning the Data, Partitioning the Algorithms, Handling Inter-partition Dependencies, Probability and Statistics for Simulations and Analysis, Introduction to Queues and Random number, Random Variates Generation, Sensitivity Analysis.	10	3,4		
	**Assignment Topics					
Module 4: < Simulations Results	in class	Display Forms: Tables, Graphs, and Multidimensional Visualization, Terminals, X and MS Windows, and Web Interfaces, Validation of Model Results.	9	4		

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Analysis and Viewing Tools & Simulation Languages >		Simulation Languages : Comparison and selection of simulation languages, study of anyone simulation language.				
	**Assignment Topics					
Module 5: < Case Studies>	in class	Development of simulation models using simulation language studied for systems like queuing systems, Production systems, Inventory systems, maintenance and replacement systems and Investment analysis.	6	4,5		
	**Assignment Topics					

Text Books:

1. Averill M Law, Simulation Modeling and Analysis, 4th Ed., Tata Mcgraw Hill Companies.
2. Banks, Carson, Nelson and Nicol, Discrete-Event System Simulation, Pearson Education.

Reference Books:

1. Geoffrey Gordon, System Simulation, Prentice Hall.
2. Raj Jain, John, the Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation and Modeling, Wiley & Sons Inc.
3. Ross, Sheldon M, Simulation, Elsevier: Amsterdam.
4. V.P.Singh, System Modeling& Simulation, New age International publisher.

Sub Code: CS510A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED COMPUTER NETWORKS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course presents a detailed study in various aspects of Computer Networking applications, protocols and technologies associated with various layer of protocol stack. A comprehensive approach in various levels of security threats and their counter measures is also covered in the course.

Pre-requisites: Communication Techniques, Data Communication and Computer Network.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Identify the main abstract concepts related to the layered communication architecture.
2. Analyze and implement some of the most advanced routing and congestion control algorithms.
3. Evaluate the performances of computer networks (through mathematical modeling and simulation).
4. Practice network simulators.
5. Explain basics and principles of new generation of computer networks (VPN, wireless networks, mobile networks, etc.).

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Network Layer: Routing Protocols for Wired Network >	in class	Unicast Routing Protocols: Shortest Path, Flooding, DVR, Link State Routing, Multi Cast Routing Protocols, Interior Gateway Protocol :OSPF, Exterior Gateway Protocol : BGP.	8	1		
	**Assignment Topics					
Module 2: < Routing Protocols For Mobile Wireless Network >	in class	Cellular Network, HAWAII, Mobile IPv4, Mobile IPv6: Overview, Header, Route Optimization, Handover Management, HMIPv6: Overview, MAP Discovery, Local Mobility Management in HMIPv6.	9	1,2		
	**Assignment Topics					
Module 3: < Transport Layer: Functions Of Transport Layer Protocols >	in class	Congestion control, Reliable service, Introduction to TCP as Transport Layer Protocol: Header Description, Congestion Control mechanism of TCP, TCP newReno, Tahoe, Connectionless UDP: Use of UDP, Header Description,, Real-time Transport Protocol (RTP), SCTP, Wireless TCP, SNOOP.	9	2,3		
	**Assignment Topics					
Module 4: < Application Layer >	in class	Domain Name Systems: Name Space (Flat and Hierarchical), Domain Name Space: Label Domain Name, Domain, Distribution of Name Space: Hierarchy of Name Servers, Zones, Root, Servers, Primary and Secondary Servers, DNS in the Internet. E-mail: - Architecture and Services, Message Formats. World	9	3,4		

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		Wide Web:- Architectural Overview, HTTP, Performance Enhancements.				
	**Assignment Topics					
Module 5: <Network Security >	in class	Cryptography, Symmetric Key Algorithms: - DES, Public Key Algorithms: - RSA. Digital Signatures: - Symmetric Key Signatures, Public Key Signatures, Message Digests.	5	5		
	**Assignment Topics					

Text Books:

1. Andrew S Tanenbaum, Computer Networks, PHI.
2. Behrouz A Forouzan, Introduction to Data Communication and Networking.

Reference Books:

1. William Stalling, Data and Computer Communications, PHI.
2. HeshmanSoliman, Mobile IPv6 Mobility in a Wireless Internet, Pearson Education

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Sub Code: CS511A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED SOFTWARE ENGINEERING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides a detailed explanation on various phases of software development life cycle along with a wide perspective on software development, including requirements analysis, technical design, estimating, programming style, testing, quality measures and management issues. Various models of SDLC in theory and practice are discussed along with a study on various metrics of software for better planning, design and implementation of efficient software systems.

Pre-requisites: Data Structures, Database Management System and Object Oriented Concept, Software engineering.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Demonstrate a comprehensive understanding of the process of developing a software system from requirements analysis and design to implementation and testing.
2. Illustrate systematic knowledge and understanding of a range of object-oriented modelling techniques and demonstrate originality in their appropriate application.
3. Analyse and evaluate the implications of object-oriented approaches to the modelling of business systems, communicating effectively using well-reasoned, logical arguments.
4. Interface with other software systems such as databases.
5. Demonstrate comprehensive knowledge and understanding of a range of techniques to enhance the quality of software and apply appropriately.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < System Engineering - Analysis & Design >	in class	System, systems engineering process- system analysis and design, modeling tools, tools for representations, various life cycle models, their advantages and disadvantages, and its applicability.	5	1		
	**Assignment Topics					
Module 2: < Software Architectures &Design and Software Metrics >	in class	Software Architectures &Design:Function oriented architecture and design scheme, Object oriented architecture and design scheme, Service oriented architecture and design scheme and its applicability. Software Metrics: Basic parameters to be estimated, types of estimation, parameters (metrics) for estimation SLOC, function point, feature point	10	2		
	**Assignment Topics					
Module 3: < Software Testing Strategies &	in class	Software Testing Strategies: Testing methods- The box approach, White-box testing, Black-box testing, Grey-box testing, Visual testing. Testing levels- Unit testing, Integration testing, System testing, System integration testing.	9	3,4		

Software Reliability >		Software Reliability: The bathtub curve for software reliability. Available tools, techniques, and metrics, Software reliability models, Software reliability metrics, Software reliability improvement techniques				
	**Assignment Topics					
Module 4: < Software Re-use, Re-engineering - reverse engineering & Real-time Software Engineering >	in class	Software Re-use, Re-engineering - reverse engineering: Basics issues in any reusable program, various reuse approaches, stumbling blocks in reuse of components. Importance of reverse engineering, Steps in reverse engineering. Real-time Software Engineering: Real-time requirements analysis, architecture for real-time systems, its design and modelling, test schemes	8	4,5		
	**Assignment Topics					
Module 5: < Client/Server Software Engineering & Object-oriented Software Engineering >	in class	Client/Server Software Engineering: 3-tier architecture, components of Client/Server Software systems, Design Issues for C/S Systems, Architectural Design for Client/Server Systems, C/S Design Approach Object-oriented Software Engineering : OO-Analysis, OO-Design, OO-Testing, metrics for OO systems.	8	5		
	**Assignment Topics					

Text Books:

1. Rajib Mall, "Fundamentals of Software Engineering", PHI.
2. Richard Fairley, "Software Engineering Concepts", Tata McGraw Hill.

Reference Books:

1. JalotePankaj, "An integrated approach to Software Engineering", Narosa.
2. Pressman R, "Software Engineering- Practioner Approach", McGraw Hill.
3. Somerville, "Software Engineering", Pearson
4. Budgen, "Software Design", Pearson

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Sub Code: CS512A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED SOFT COMPUTING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides a comprehensive study on various computational techniques (such as Genetic Algorithm, ANN, Fuzzy Logic etc.) used in computer science for modelling or solving complex problems for which more conventional methods have not yielded low cost, analytic and complete solutions.

Pre-requisites: Data Structures, Design and Analysis of Algorithms and Artificial Intelligence.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Explain neural network(NN) paradigms.
2. Identify fuzzy logic applications.
3. Apply the evolutionary computations, genetic algorithm(GA), evolutionary programming, classifier systems, genetic programming parse trees, mathematical foundation of GA variants of GA.
4. Formulate solutions to real life engineering problems using soft computing principles.
5. Develop solutions to real life engineering problems using soft computing principles.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction & Fuzzy Set Theory >	in class	Introduction: Definition and Concept of Soft Computing, Aspects of Soft Computing, Dealing with Vagueness- Fuzzy Systems, Rough Sets, Modeling the Brain-Human Cognition, Artificial Neural Networks, Modeling Nature's Optimization Process- Natural Evolution, Genetic Algorithms, Other Evolutionary Processes, Synergy Among the Soft Computing Techniques Fuzzy Set Theory: Review of Crisp Set theory - Sets and subsets, Definitions, Concepts, Notations and Operations on sets, De Morgan's Law, Fuzzy Sets – Fuzziness/vagueness, Membership function - Crisp membership, Fuzzy membership, Membership profiles, Fuzzy sets - Definition, Notation, Features, Transformation. Fuzzy Membership Functions -Some Popular Membership Function, Transformations on Membership Functions, Fuzzy set operations, Properties, De Morgan's Law, Fuzzy Relations, Operations on fuzzy relations	10	1		
	**Assignment Topics					
Module 2: < Fuzzy Logic & Propositional Logic >	in class	Fuzzy Logic: Fuzzy Logic Basics, Fuzzy Truth as Fuzzy Membership, Fuzzy Truth and Linguistic Variables, Fuzzy Rules, Fuzzy Quantifiers, Generalized Modus Ponens, Fuzzy Inference, Generalized Modus Tollens Propositional Logic: Propositions, Propositional logic well-formed formulae, Properties of wffs, Interpretation of logical expression, Logical equivalence, Tautology/ Contradiction/ Consistency, Validity of an argument	9	2,3		

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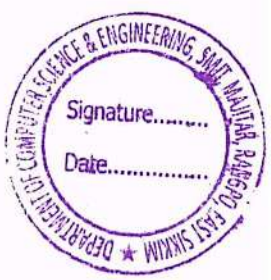
	**Assignment Topics					
Module 3: < Predicate Logic & Rough Sets >	in class	Predicate Logic: Limitations of propositional logic, Predicate logic well-formed formulae, Properties of FOPL wffs, Rules of Inference, Deductive Rules, Modus ponens, Universal Specialization, Chain Rule, Simplification, Resolution, Modus Tollens, Addition, Non-deductive Rules, Abduction, Induction, Analogy. Rough Sets : Information Systems & Decision Systems, Indiscernibility, Set Approximations-Lower & Upper Approximations, Rough set properties, Rough Membership: Rough Membership Function, Properties, Rough set Categories, Roughly B-definable, Internally B-definable, Externally B- definable, Totally B-definable, Reducts: Reduct & Minimal Reduct, Discernibility Mattrix & Discernibility Function	11	3,4		
	**Assignment Topics					
Module 4: < Artificial Neural Networks >	in class	Artificial Neural Networks : Basic Concepts-The Biological Neuron, The Artificial Neuron, Characteristics of the Brain, Computation in Terms of Patterns -Pattern Classification, Pattern Association, The McCulloch- Pitts Neural Model, The Perceptron, Neural Network Architectures - Learning by Neural Nets, Multilayer Feed forward, The Back propagation Algorithm - Learning, Parameter Choice, Initialization, Stopping criteria, Training set, Data Representation, Hidden Layers.	5	4,5		
	**Assignment Topics					
Module 5: <Advanced Search Algorithms >	in class	Genetic Algorithms - Natural Evolution, Chromosomes, Natural Selection , Cross-over, Mutation, Basic GA, Encoding a solution as chromosome / decoding it, Fitness Function, Population, GA operators- Selection, Tournament, Roulette Wheel, Cross-over, Mutation, GA parameters , Convergence	5	4,5		
	**Assignment Topics					

Text Books:

1. J.-S.R. Jang, C. -T. Sun, E.Mizutani, "Neuro-Fuzzy And Soft Computing-A Computational Approach to Learning and Machine Learning", Pearson Education.
2. LaureneFausett, "Fundamentals of Neural Networks – Architechture, Algorithms and Applications", Prentice Hall.

Reference Books:

1. Simon Haykin, "Neural Networks – A Comprehensive Foundation", Prentice Hall.



Sub Code: CS513A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: OBJECT ORIENTED ANALYSIS AND DESIGN USING UML

Questions to be set: 05 (All Compulsory)

Course Objectives: This course delves into the processes of both object-oriented analysis and object- oriented design using UML as the notation language to provide a common, standard notation for recording both analysis models and design artifacts. Facets of the Unified Process approach to designing and building a software system are also covered.

Pre-requisites: Object oriented Design concepts, Design & Analysis of Algorithms and software engineering.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define standard Unified Modelling Language (UML) notation.
2. Model requirements with Use Cases.
3. Describe the dynamic behaviour and structure of the design.
4. Describe Object Oriented Analysis and Design concepts and apply them to solve problems.
5. Prepare Object Oriented Analysis and Design documents for a given problem using UML.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction, Modeling Concepts & Class Modeling>	in class	Introduction: Development and OO Modeling History. Modeling Concepts: Three models, Class Model, State model and Interaction model. Class Modeling: Object and class concepts, link and association, Advanced class modeling- aggregation, Abstract class metadata, constraints.	12	1,2		
	**Assignment Topics	About Object Orientated Technology, Modeling design Technique, Generalization and Inheritance.				
Module 2: < State Modeling & Interaction Modeling >	in class	State Modeling: Event, state, Transition and conditions, state diagram, state diagram behavior, concurrency, Relation of Class and State models. Interaction Modeling : Use case Models, sequence models, activity models	8	2,3		
	**Assignment Topics					
Module 3: < Analysis and Design >	in class	Development stages, Domain Analysis-Domain class model, domain state model, domain interaction model, Iterating and analysis. Application Interaction model, Application class model, Application state Model, Adding operation.	7	3,4		
	**Assignment Topics	Development Life cycle				
Module 4: < System Design>	in class	Estimating Performance, breaking system into subsystems, identifying concurrency, allocation of subsystems, management of data storage, Handling Global resources, choosing a software control strategy,	7	3,4		

		Handling boundary condition, common Architectural style.				
	**Assignment Topics	Making a reuse plan				
Module 5: <Class design>	in class	Designing algorithms recursing downward, refactoring, design optimization	6	5		
	**Assignment Topics	Overview of class design, Adjustment of Inheritance, Reification of Behavior				

Text Books:

1. Michael R Blaha, James R Rumbaugh, "Object-Oriented Modeling and Design with UML", Pearson.
2. Ali Bahrami, "Object Oriented Systems using the United Modeling Language", McGraw Hill.

Reference Books:

1. Grady Booch, James Rumbaugh, Ivar Jacobson, "The Unified Modeling Language", Pearson Education.
2. Grady Booch, "Object Oriented Analysis and Design", Pearson Education.
3. Graig Larman, "Applying UML and Patterns", Addison Wesley.
4. Perdita Stevens, Rob Pooley, "Using UML Software Engineering with Objects and Components",Pearson.

Sub Code: CS514A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ARTIFICIAL INTELLIGENCE

Questions to be set: 05 (All Compulsory)

Course Objectives: The aim of this course is to provide an introduction to some fundamental issues and algorithms in artificial intelligence (AI). The course approaches AI from an algorithmic, computer science-centric perspective. The course aims to provide some fundamental tools and algorithms required to produce AI systems able to exhibit limited human-like abilities, particularly in the form of problem solving by search, representing and reasoning with knowledge, planning, natural language understanding, computer vision, automatic programming and machine learning.

Pre-requisites: Algorithms will be an essential component, in addition the course requires some mathematics specially Calculus, Probability and statistics. Natural Sciences Mathematics or equivalent, and Discrete Mathematics, are likely to be helpful although not essential. Mathematical Methods for Computer Science, Probability, Logic and Proof, Prolog and Complexity Theory are likely to be useful.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Distinguish between the popular view of the field and the actual research results.
2. Appreciate the fact that the computational complexity of most AI problems requires us regularly to deal with approximate techniques.
3. Describe different perspectives on what the problems of artificial intelligence are and how different approaches are justified.
4. Design basic problem solving methods based on AI-based search, knowledge representation, reasoning, planning, and machine learning algorithms.
5. Identify problems requiring AI based solutions.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: <Introduction to Artificial Intelligence & Machine Learning>	in class	Introduction: Definition of AI, Overview of Artificial Intelligence- Problems of AI, AI techniques, Turing test, Typical AI problems: Tic -Tac- Toe problem, 8-puzzle problem, 8-Quenes problem. Machine Learning: Learning- Supervised and Unsupervised learning, adaptive Learning, Reinforcement learning, Linear classification, Loss minimization, Stochastic gradient descent, K-Means Algorithm, The perceptron. Learning by gradient descent. Multilayer perceptron and the back propagation algorithm, Deep learning, Auto-encoders, CNNs, RNNs, Introduction to Natural Language Processing.	10	1		
	**Assignment Topics	Intelligent and Rational agents , Practical impact of AI				
Module 2: <Problem solving by	in class	Problem solving by Search : Tic -Tac- Toe problem, 8-puzzle problem, 8-Quenes problem. State space search, Uninformed search strategies: BFS, DFS, Depth Limited	11	2		

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Search & Informed Search Techniques>		search, Iterative Deepening DFS, Bi-directional depth first search. Informed Search Techniques : Informed (Heuristic) Search Strategies, Best First Search (BFS), Greedy BFS, A* Search, Heuristic Functions, Iterative-Deepening A*, Hill Climbing Search, Genetic Algorithms.				
	**Assignment Topics	Problems, Problem Space & search, Formulating problems: Pegs and Disks problem, Missionary Cannibals problem ,Simulated Annealing Search, Local Beam Search.				
Module 3: < Adversarial Search & Bayesian Networks>	in class	Adversarial Search : Game Trees, Optimal Decision in Games: Minimax Algorithm, Alpha Beta Pruning, TD learning, Game theory. Bayesian Networks : Bayesian inference, Marginal independence, Hidden Markov models, Learning Bayesian networks, Laplace smoothing, Expectation Maximization, Representing knowledge in an uncertain domain, the semantics of Bayesian networks, Dempster-Shafer theory, Fuzzy sets & fuzzy logics.	7	3		
	**Assignment Topics					
Module 4: < Constraint Satisfaction Problems >	in class	Constraint Satisfaction Problems: N-Queen problem, Crossword puzzle, Map coloring problem, Boolean satisfiability problem (SAT). The backtracking algorithm for CSPs. Heuristics for improving the search for a solution. Forward checking.	7	4,5		
	**Assignment Topics	Constraint propagation and arc consistency. Backtracking, Back jumping using Gaschnig's algorithm, Graph-based back jumping.				
Module 5: < Knowledge representation and Reasoning >	in class	Logic programming, forward verses backward reasoning, matching, control knowledge.	8	5		
	**Assignment Topics	Knowledge representation issues, representation & mapping, approaches to knowledge representation, representing simple fact in logic, Syntax versus semantics, Propositional logic, Predicate logic, Horn clauses, First-order logic Resolution, representing instant & ISA relationship, computable functions & predicates, resolution, natural deduction. Procedural verses declarative knowledge				

Text Books:

1. Russell, S. & Norvig, P. (2010). Artificial intelligence: a modern approach. Prentice Hall (3rd ed.).
2. Elaine Rich, Kevin Knight & Shivashankar B. Nair (2008). Artificial Intelligence (Third Edition) TMH.
3. Bishop, C. M. (2006) Machine Learning and Pattern Recognition. Berlin: Springer.

Reference Book:

1. Poole, D. L. & Mackworth, A. K. (2010). Artificial intelligence: foundations of computational agents. Cambridge University Press.

Sub Code: CS515A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: INTERNET OF THINGS

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide students with a foundation in computing, communication and information technologies.by making student to realize the revolution of Internet in Mobile Devices, Sensor Networks and Cloud technology. Also to develop the teamwork skills, multidisciplinary approach, and an ability to relate information technology to overcome real world and social issues inducing students with good computing and communication knowledge so as to understand, analyze, design, and innovate a new system.

Pre-requisites: Computer Networks, knowledge of basic Wireless & Wired Networking, Wireless Sensor Networks and programming language.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Visualize the impact of information technology solutions on the society.
2. Identify the application areas of IOT.
3. Identify building blocks of Internet of Things and characteristics.
4. Establish interconnection and integration of the physical world and the cyber space.
5. Design & develop IOT Devices.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction to Internet of Things (IoT)>	in class	Introduction to Internet of Things (IoT): Fundamentals of Internet of Things, IoT Definition, Characteristics of IoT, IoT Vision, IoT Functional View, Application Areas.	4	1		
	**Assignment Topics					
Module 2: < Domain Specific IOTs >	in class	Domain Specific IOTs : Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Life Style.	6	2		
	**Assignment Topics					
Module 3: < IoT Technology Fundamentals>	in class	Architectural overview, Components of IoT system, Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, IoT analytics, Knowledge management	10	3		
	**Assignment Topics					
Module 4: < Design principle for IoT >	in class	Design principle for connected devices, IoT system layers and design standardization, Networks and Communication: Networking Technology and Communication Technology, Protocols in IOT, Security, Privacy & Trust in IoT.	10	4		

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	**Assignment Topics					
Module 5: <Hands-on-IoT & IoT opportunity and challenges >	in class	Hands-on-IoT : IoT Physical Devices & Endpoints: What is an IoT Device, Exemplary Device, Board, Linux on Raspberry Pi, Interfaces, Types of sensors. IoT opportunity and challenges : Various case studies, opportunity and challenges in IoT.	10	5		
	**Assignment Topics					

Text Books:

1. Ovidiu Vermesan,Peter Friess"Internet of Things –From Research and Innovation to market Deployment",River Publishers.
2. Jan Ho¨ ller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand,
3. David Boyle "From Machine-to-Machine to the Internet of Things Introduction to a New Age of Intelligence",Academic Press Elsevier.
4. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-onApproach)", I st Edition, VPT, 2014.

Reference Books:

1. "Internet of Things" Copyright 2016 by Tutorials Point (I) Pvt. Ltd.
2. Tim O'Reilly & Cory Doctorow "Opportunities and Challenges in the IoT",O'Reilly publication.
3. Pethuru Raj , Anupama C.Raman,"The Internet of Things, Enabling Technologies,platforms and use cases", CRC Press.

Sub Code: CS516A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: INTELLECTUAL PROPERTY RIGHTS

Questions to be set: 05 (All Compulsory)

Course Objectives: To introduce the role and importance of Intellectual property rights in the field of information technology. To understand the concepts of patents, trademarks and copyrights. To introduce the procedure for obtaining patents, trademarks and copyright.

Pre-requisites: NIL.

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Identify the principle of intellectual property Rights and its importance in the field of information technology.
2. Analyse the important of patentee trademarks and copyright.
3. Describe the procedure for obtaining patent, registering a trademarks and owning copyrights.
4. Recommend the use of IPR in real life scenarios.
5. Identify licensing and legal issues with FOSS.

** not more than 20% of total topics to be allotted for assignment

Module	Topics to be covered	Topics	Hrs	CO	PO	PSO
Module 1: < Introduction to Intellectual Property Rights>	in class	Intellectual Property, Introduction to IPR, History of IPR, Overview & Importance, Role of IPR in Research & Development, Legislations Covering IPRs in India, Different forms of IPR – Patents, Copyright, Trademark, Industrial Designs, Layout Designs of Integrated Circuits, Geographical Indications, Some important examples of IPR.	8	1,2		
	**Assignment Topics	Trade Secrets, Plant Varieties,				
Module 2: < Patents >	in class	Introduction, Patent – A form of property, The Patent Law in India, Patent Document, Protectable Subject matter: Patent and kind of inventions protected by a patent, Inventions which are not patentable under the act, Patent of addition, Term of patents of addition. Why protect inventions by patents? Searching for patents, Filing of a patent.	6	2,3		
	**Assignment Topics	Drafting of a patent, Rights Conferred to Patentee.				
Module 3: < Copyright & Trademark>	in class	Copyright: Introduction, Meaning of copyright, Characteristics of copyrights, Indian Copyright Law. Main features of Copyright Act 1957, Amendments to Copyright Act, Requirements of copyrights, Copyright are protection in form and not in idea, Authorship and ownership of copyright. Rights conferred by copyright,	10	3,4		

		Term of copyright, Related rights, Distinction between related rights and copyright. Trademarks: Meaning of Trademark, the Functions of a Trademark, Essentials of a Trademark, Trademark Law in India, Domain name and how does it relates to trademarks? Registration of Trademark. Rights conferred by registration of Trademark.				
	****Assignment Topics**					
Module 4: < IPR in the field of Information Technology & Computer Ethics >	in class	IPR in the field of Information Technology: Introduction, Information Technology Act - 2000, Offences and corresponding penalties – Section 65 to 71, Section 66A and restriction of free speech, National Cyber Security Policy – 2013, Some notable cases. Computer Ethics : Definition of Ethics, Computer and Information Ethics, The Ten Commandments of computer ethics, Hacking, Ethical hacking, Plagiarism.	8	4,5		
	****Assignment Topics**					
Module 5: < Open Source Software >	in class	Introduction to Free and Open Source Software (FOSS), Open Source vs. Closed Source, Free Software, Free Software vs. Open Source software, Licenses: GNU General Public License (GPL), MIT License, BSD License, Mozilla Public License, Apache License. Creative Commons, Public Domain, Forking Open Source projects.	8	5		
	****Assignment Topics**	Copyright vs. Copyleft, Violation of copyrights and remedies, Using Open Source projects in industry, Open Source Government, Open Source Hardware, Open source media.				

Text Books:

1. Dr. B. L. Wadhera, Law Relating to Intellectual Property, Universal Law Publishing Co. Ltd.
2. P. Narayanan; Law of Copyright and Industrial Designs; Eastern Law House, Delhi

Reference Books:

1. Ajit Parulekar and Sarita D' Souza, Indian Patents Law – Legal & Business Implications; Macmillan India Ltd. 2006
2. National Cyber Security Policy, 2013.
3. Information Technology Act – 2000.

Sub Code: CS517A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: MACHINE LEARNING: THEORY AND METHODS

Questions to be set: 05 (All Compulsory)

Course Objectives: It reflects recent developments while providing a comprehensive introduction to the fields of pattern recognition and machine learning. It is aimed at advanced undergraduates assuming no previous knowledge of pattern recognition or machine learning concepts

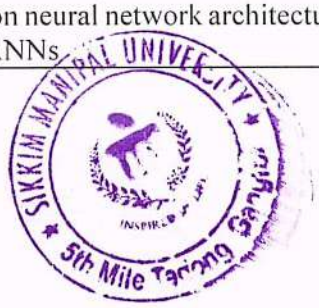
Pre-requisites: Knowledge of multivariate calculus and basic linear algebra and basic probability theory

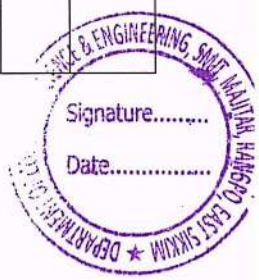
Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Identify methods to solve ML problems.
2. Design pattern recognition program systems using approaches of these theories for solving various real-world problems.
3. Identify importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent machines.
4. Describe areas of application of ML.
5. Formulate solution strategies for solving ML problems in real life.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction and Linear Models for Regression	in class	Polynomial Curve Fitting, Probability Theory: Expectations and Co-variances, Bayesian probabilities, The Gaussian distribution, Curve fitting re-visited. Linear Basis Function Models: Maximum likelihood and least squares, Sequential learning, Regularized least squares	10	1		
	**Assignment Topics	The Bias-Variance Decomposition: Bayesian Linear Regression, Parameter distribution, Predictive distribution				
Module 2: Linear Models for Classification	in class	Discriminant Functions: Two classes, Multiple classes, Least squares for classification, Probabilistic Generative Models: Continuous inputs	6	2		
	**Assignment Topics	Maximum likelihood solution, Probabilistic Discriminative Models: Fixed basis functions, Logistic regression.				
Module 3: Sparse Kernel Machines and Kernel Methods	in class	Maximum Margin Classifiers: Overlapping class distributions, Relation to logistic regression, Multiclass SVMs, Dual Representations, Constructing Kernels, Radial Basis Function Networks.	9	3		
	**Assignment Topics					
Module 4: Neural Networks	in class	Basic concepts: The artificial neuron, The McCulloch- Pitts neural model, The perceptron neural network architectures: Single layer feed forward ANNs	6	4,5		





	**Assignment Topics	Multi-layer feed forward ANNs, Activation function, Generalized delta rule, The Back propagation Algorithm: Learning, Parameter optimization, Convolutional networks: Auto-sparse encoders				
Module 5: Mixture Models and EM, Continuous Latent Variables and Sequential Data	in class	K-means Clustering, Mixtures of Gaussians, Maximum likelihood. Principal Component Analysis: Maximum variance formulation, Markov Models, Hidden Markov Models, Maximum likelihood for the HMM,	10	5		
	**Assignment Topics	EM for Gaussian mixtures, Applications of PCA, PCA for high-dimensional data, The forward- backward algorithm.				

Text Books:

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer.

2. David J.C. Mackay, "Information Theory, Inference and Learning Algorithms", Cambridge University Press, 2003.

Reference Books:

1. Andrew Ng, "Lecture Notes on Machine Learning".

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Sub Code: CS518A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: ADVANCED OPERATING SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objectives: The aim of this module is to study, learn, and understand the main concepts of advanced operating systems (parallel processing systems, distributed systems, real time systems, network operating systems, and open source operating systems); Hardware and software features that support these systems.

Pre-requisites: Operating Systems, Real Time Systems, Distributed Systems

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Explain and manipulate the different concepts in advanced operating systems.
2. Summarize the major security issues associated with distributed systems along with the range of techniques available for increasing system security.
3. Select appropriate approaches for building a range of distributed systems, including some that employs middleware.
4. Apply standard design principles in the construction of these systems.
5. Compose methods for analyzing the performance of various identified algorithms or techniques in advanced operating systems.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Concepts	in class	Hardware concepts of distributed systems, Software concepts and design issues, Communication in distributed systems	10	1		
	**Assignment Topics					
Module 2: Threads and Procedure Calls	in class	Threads and thread usage, Multithreading operating system, Client – server model, Implementation of Client-server model,	10	1,3		
	**Assignment Topics	Remote procedure call, Implementation of remote procedure call				
Module 3: Synchronization	in class	Synchronization in distributed systems, Clock synchronization, Mutual exclusion, Election algorithms, Transaction and concurrent control	10	2,3		
	**Assignment Topics					
Module 4: Deadlocks	in class	Deadlock in distributed systems, Processor Allocation, Real – time distributed systems,	8	3,4		

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	**Assignment Topics					
Module 5: Distributed file systems	in class	Distributed file systems	2	5		
	**Assignment Topics					

Text Books:

1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, "Operating System Concepts", Wiley & Sons.Inc..
2. D M Dhamdhere, "Systems Programming & Operating Systems", Tata McGraw-Hill.

Reference Books:

1. Andrew S. Tanenbaum, "Modern Operating systems", PHI.
2. Mukesh Singhal, Niranjan G.Shivaratri, "Advanced Concepts in Operating Systems", Tata McGraw- Hill.
3. P. Balakrishna Prasad, "Operating Systems", Scitech Publication.
4. William Stallings, "Operating Systems-Internals and Design Principles", Pearson Education.

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Sub Code: CS519A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: QUEUING THEORY AND MODELING

Questions to be set: 05 (All Compulsory)

Course Objectives: To make students familiar with stochastic process theory and its applications and to develop mathematical and modeling skills required for evaluating queueing systems performance also to give a theoretical background needed to understand academic literature on the subject.

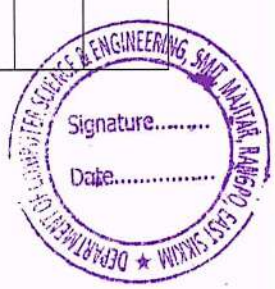
Pre-requisites: Adequate knowledge of undergraduate mathematics

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Apply probability techniques, models to analyse the basics of queuing theory
2. Identify the areas and hence apply the mathematical techniques necessary
3. Apply knowledge of continuous time stochastic processes for deeper understanding
4. Design resources to meet specified required quality of service of a queueing system
5. Develop ability to identify, evaluate, formulate and solve engineering problems related to resource allocation of queueing system.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction	in class	Introduction to Queues and Queueing Theory. Stochastic Processes, Markov Processes and Markov Chains, Birth-Death Process.	6	1		
	**Assignment Topics					
Module 2: Basic Queueing Theory	in class	Basic Queueing Theory (M/M/-/- Type Queues. Departure Process from M/M/-/- Queue, Time Reversibility, Method of Stages, Queues with Bulk Arrivals.	6	2		
	**Assignment Topics					
Module 3: M/G/1 Queue	in class	Equilibrium Analysis of the M/G/1 Queue. Analyzing the M/G/1 Queue using the Method of Supplementary Variables. M/G/1 Queue with Vacations. M[x]/G/1 Queue. Priority Operation of the M/G/1 Queue.	8	3		
	**Assignment Topics					
Module 4: M/M/n/K Queue and Queueing Networks	in class	M/M/n/K Queue with Multiple Priorities. M/G/1/K Queue. G/M/1, G/G/1 G/G/m, and M/G/m/m Queues. Classification and Basic Concepts, Open and Closed Networks of M/M/m Type Queues, Jackson's Theorem	10	4,5		
	**Assignment Topics	Analysis of Closed Queueing Networks using Convolution and Mean Value Algorithms.				



Module 5: Queueing Networks	in class	Norton's Theorem for Closed Queueing Networks, Mixed Queueing Networks, Queueing Network Analyzer (QNA) Approach, Discrete Time Queues.	10	4,5		
	**Assignment Topics	Simulation Techniques for Queues and Queueing Networks.				

Text Books:

1. Donald Gross, James M. Thompson, John F. Shortle and Carl W. Harris, Fundamentalsof Queueing Thoery, Wiley 2008.

Reference Books:

1. Sanjay K. Bose, An Introduction to Queueing Systems, Springer 2002.

Sub Code: CS520A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: COMPUTER VISION

Questions to be set: 05 (All Compulsory)

Course Objectives: This course highlights the overview of display devices and peripherals software and techniques used in computer graphics. It also introduces graphics processing to general purpose parallel computing. Study high-definition 3D graphics, programmable graphic processor unit, multithreaded processor, multi core processor with tremendous computational horsepower and very high memory bandwidth.

Pre-requisites: Programming concepts, object oriented concept

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Apply mathematical and engineering fundamentals in the perspective of computer vision
2. Identify problems that can be solved using computer vision techniques
3. Explain the importance of tolerance of imprecision and uncertainty for design of robust and low-cost intelligent machines
4. Determine a problem to identify technical issues and solve the problems using various computer vision techniques
5. Design real-life applications using computer vision techniques

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction, overview of graphics systems, overview of OpenGL	in class	Display devices, Hard copy devices, Interactive input devices, Display processors. Introduction to openGL, DirectX, Comparison between OpenGL and DirectX.	6	1		
	**Assignment Topics					
Module 2: Output primitives Attributes of output primitives	in class	Points and lines, Line drawing algorithm, Anti-aliasing lines, Circle generating algorithms (Bresenham's), Ellipse, Other curves, Character generation Line styles, Color and intensity, Solid area scan conversion, Character attributes,	8	2		
	**Assignment Topics	Inquiry functions, Bundled attributes				
Module 3: Two dimensional ansformations Windowing and clipping	in class	Basic Transformations, Homogenous co-ordinates, Composite Transformations, Reflections, Shear Windowing concepts, Clipping algorithms, Line clipping (Cohen Sutherland & Mid-point sub division), Area Clipping, Text Clipping, Window to view port transformation	8	3		
	**Assignment Topics					

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Module 4: Introduction to CUDA CUDA Programming Model	in class	From Graphics Processing to General-Purpose Parallel Computing, CUDA™ a General- Purpose Parallel Computing Architecture, Document's Structure Kernels, Thread Hierarchy, Memory Hierarchy, Host and Device, Compute Capability	8	4		
	**Assignment Topics	CUDA's Scalable Programming Model.				
Module 5: CUDA Programming Interface Hardware Implementation Computer Animation	in class	Compilation with NVCC, C for CUDA- Device Memory, Shared Memory, Multiple Devices, Texture Memory-Texture Reference Declaration, A Set of SIMT Multiprocessors with On-Chip Shared Memory, Multiple Devices. Introduction, Types of animation, Principles of Animation, General Computer-Animation Functions, Computer-Animation languages, Key frame systems morphing,	12	5		
	**Assignment Topics	Runtime Texture Reference Attributes, Texture Binding. Animation Tools, Animation using HTML5.				

Text books:

1. Donald Hearn & M. Pauline Baker, "Computer Graphics", PHI.
2. NVIDIA CUDA™ Programming Guide Version 2.3.1
3. NVIDIA CUDA C Programming Guide PG-02829-001_v7.0
4. Donald Hearn & M. Pauline Baker, "ComputerGraphics with OpenGL", PHI.

Reference books:

1. Steven Harington, "Interactive Computer Graphics", Tata McGraw Hill.
2. Dabod G. Rfgers, "Procedure elements for Computer Graphics", McGraw Hill.
3. A. Plastick& Gordon Kalley , "Computer Graphics, Schaum's Outline series", McGraw Hill.
4. Amarendra N Sinha and Arun D Udai , "Computer Graphics", McGraw Hill.

Sub Code: CS521A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: BLOCK CHAIN CODING

Questions to be set: 05 (All Compulsory)

Course Objectives: The syllabus is aimed at giving a basic understanding of cryptocurrency, its importance and the use of block chain technology. It is focused on defining the technological backbone of Bitcoin fundamentals and expands the concepts to building the block chain technology. It guides us to understand the history of digital currency, the polices involving laws and organizations, the latest trends, and the communities involved; which facilitates us to construct, visualize and understand the ecosystem of block chain technology and its environment on which it is deployed.

Pre-requisites: Basics of Cryptography and Economics

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Describe crypto currencies and block chain fundamentals.
2. Explain individual building blocks and understand the working mechanism of any block chain technology.
3. Discover the modern engineering tools, techniques and resources in the field of block chain technology.
4. Differentiate between different versions of block chain technology.
5. Illustrate use of block chain technology in a broader context like health, banking sector and identify security concerns in block chain technology.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction Basics	in class	Trustless system, Decentralized transactions. History: How and when Block chain & Bitcoin started, Milestones on the development of bit coin: creation, exchanges, Bitcoin: Nakamoto consensus, Research Perspectives & Challenges, Bitcoin mining strategy and attacks, Bitcoin community, economics & politics. Block Chain: What is Block chain? Distinction between Blockchain vs Cryptocurrency vs Token, Pillars of Block chain , Industry Applications of Blockchain.	10	1,2		
	****Assignment Topics**	Crypto currencies: Bitcoin / Ethereum, How to Buy Bitcoin/Ethereum - How to Set up a Wallet.				
Module 2: Working Mechanism Mining and Cryptocurrencies	in class	How Blockchain (and Bitcoin) Work, Peer to Peer network, What is a block?, block chain drive : Proof of Work, Byzantine Generals, Distributed consensus, Cryptography: Hashing, Data Integrity, Merkle Trees, Public v Private Key Cryptography, Bitcoin and block sizes Mining : Proof of Work v Stake, how miners make money- business model, overview, the purpose, impact to the world, Motivations, incentives, strategy. Pools : CPUS and GPUs,	10	2		

	**Assignment Topics	Revenue at a Protocol Level : Block Rewards/Fees/ETC				
Module 3: Blockchain Types	in class	Public and Private Blockchains, JP Morgan Quorum, IBM's stuff, Using blockchain - Numerai, DAO, etc. Lightning networks and plasma, Sidechains, Digital Rights - ownership and accessibility, Industry - healthcare, identity, finance, Paradigm shift/future/big picture.	6	3		
	**Assignment Topics					
Module 4: Consensus Building, Regulation and Anonymity Problems with Blockchain	in class	What is it?, Security Implications, 1 PC 1 vote , Environmental, Segwit and Forks, What is a smart contract? Smart contract legal issues. Regulation and Anonymity: ICO and SEC ruling, its anonymity, Governments regulating bitcoin, Anti Money Laundering ,Political Implications on blockchain, Government's current position and its effects on blockchain. Anonymity - Zcash, Security and Safeguards, Protection from attackers, Hacks on exchanges, What is stopping adoption?, Scalability problems, Network attacks to destroy Bitcoin, Case Study: Failed currencies & Blockchain	9	4,5		
	**Assignment Topics					
Module 5: Bitcoin and Ethereum Blockchain applications	in class	Bitcoin creation and economy, Limited Supply and Deflation, Hacks , Ethereum concept and Ethereum classic, Altcoins : Major Altcoins - Zcash, Ripple, NEO Building on the Blockchain - Pros and cons of different implementations , Use cases of the different types Government, Identity management, Auto executing contracts, Three signature escrow, Triple entry accounting, Elections and voting?, Ethereum Interaction - Smart Contract and Token , Languages , How to create your own blockchain.	5	5		
	**Assignment Topics					

Text Books:

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", Kindle Edition.
2. Andreas M. Antonopoulo,"Mastering Bitcoin: Programming the Open Blockchain",2nd Edition, Kindle Edition.

Other References:

1. https://bitcoin.org/bitcoin.pdf
2. http://scet.berkeley.edu/wp-content/uploads/BlockchainPaper.pdf.

Sub Code: CS522A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: CYBER SECURITY

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is designed to present the basic concepts of cyber security. It address the key issues of security vulnerabilities on software development, operating system and the web. Solutions provided by cryptography has been discussed especially based on intrusion detection system. The syllabus also gives a brief introduction to cyber forensics.

Pre-requisites: Operating Systems, Data Communication and Computer Networks

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Discover the concepts of cyber security and its social, technical and political techniques.
2. Illustrate on the various Intrusion detection and prevention techniques.
3. Analyze various algorithms based on Cryptography and Network security.
4. Assess various methods of handling investigations in the field of cyber forensics.
5. Explain the legal and social issues in the development and management of cyber security.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction to Cyber Security Cyber Security Vulnerabilities and Cyber Security Safeguards	in class	Overview of Cyber Security, Internet Governance – Challenges and Constraints, Cyber Threats:- Cyber Warfare-Cyber Crime-Cyber terrorism-Cyber Espionage, Need for a Comprehensive Cyber Security Policy, Need for a Nodal Authority, Need for an International convention on Cyberspace Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards-Overview, Access control, Audit, Authentication, Biometrics, Cryptography, Deception, Denial of Service Filters, Ethical Hacking, Firewalls, Intrusion Detection Systems, Response, Scanning, Security policy, Threat Management.	10	1		
	**Assignment Topics					
Module 2: Securing Web Application, Services and Servers	in class	Introduction, Basic security for HTTP Applications and Services, Basic Security for SOAP Services, Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. Intrusion, Physical Theft, Abuse of Privileges,	10	1,2		

Intrusion Detection and Prevention		Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Anti-Malware software, Network based Intrusion detection Systems, Network based Intrusion Prevention Systems, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation				
	**Assignment Topics					
Module 3: Cryptography and Network Security	in class	Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec	10	3,4		
	**Assignment Topics					
Module 4: Cyberspace and the Law	in class	Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013	5	4		
	**Assignment Topics					
Module 5: Cyber Forensics	in class	Introduction to Cyber Forensics, Handling Preliminary Investigations, Controlling an Investigation, Conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E- mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time	5	4,5		
	**Assignment Topics					

Text Books:

1. John R Vacca, "Computer and Information Security Handbook", 3rd Edition, Elsevier, 2013, ISBN: 9780128038437.
2. Albert Marcella, Jr., DougMenendez, "Cyber Forensics: A Field Manual for Collecting, Examining, and Preserving Evidence of Computer Crimes", Second Edition, CRC Group, Taylor & Francis, ISBN 9780849383281.
3. William Stallings, "Cryptography and Network Security", Pearson.

Reference Books:

1. George K Kostopoulus, "Cyber space and Cyber Security ", Second Edition, CRC Group

Sub Code: CS523A3 Credit:3 (L-3, T-0, P-0)

Sub Name: COMMUNICATION SKILLS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course aims at holistic development of students and improves their employability skills.

Pre-requisites: Prior knowledge of any particular subject is not a mandatory requirement. Ability to read, write and understand English language is expected from students. After completion of the course a student is expected to show improved communication skills

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Apply knowledge of human communication and language processes as they occur across various contexts.
2. Evaluate key theoretical approaches used in inter disciplinary field of communication.
3. Choose and apply at least one of the appropriate approaches to the analysis and evaluation of human communication.
4. Assess and evaluate primary academic writing associated with the communication discipline.
5. Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Basics of Communication Comprehension and analysis	in class	Importance of Communication, stages of communication, modes of communication, barriers to communication, strategies for effective communication, listening: Importance, types, barriers, Developing effective listening skills Comprehension of technical and non-technical material, Reading for Facts, Guessing Meanings from Context, Skimming, Scanning, Inferring Meaning.	8	1		
	**Assignment Topics					
Module 2: Writing	in class	Effective sentences, cohesive writing, clarity and conciseness in writing, Better paragraphs Writing Skills – Structure and Presentation of Different Types of Writing – Letter writing/Resume Writing/ e-correspondence/ Technical Report Writing.	5	2		
	**Assignment Topics					
Module 3: Oral Communication	in class	Basics of phonetics, Group Discussions, Dialogue writing, Short Extempore, Debates, Role Plays, Conversation Practice, Code and Content, Stimulus & Response, Pronunciation Etiquette, Syllables, Vowel	7	3		

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		sounds, Consonant sounds, Tone: Rising tone; Falling Tone, Flow in Speaking, Speaking with a purpose, Speech & personality, Professional Personality Attributes, Empathy				
	**Assignment Topics					
Module 4: Business Writing / Correspondence Presentation Skills	in class	Internal Business Communication: Writing Memos, Circulars, Notices, Report writing, Instruction, Business Letters, Resumes, Job applications, communication through email Oral Presentations (individual or group), Seminars, PPTs Written Presentations through Posters, Projects, Reports, emails, Assignments, Class room presentation; style, method, Individual conferencing; essentials, Public Speaking; method; Techniques; Clarity of substance; Emotion; Humor, Overcoming Stage Fear; Audience Analysis & retention of audience interest; Audience Participation	12	4		
	**Assignment Topics					
Module 5: Technical Communication Interpersonal Communication	in class	Distinction between General and Technical Communication, Technical Report: Definition & importance, Thesis/Project writing: structure & importance, synopsis writing: Methods, Technical research Paper writing: Methods & style, Seminar & Conference paper writing Critical thinking, Discourse competence, combination of expression & conclusion, Socio- linguistic competence, Cross-cultural communication	8	5		
	**Assignment Topics					

Text Books

1. Technical Communication – Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press, 2007, New Delhi.
2. Personality Development and Soft Skills by Barun K. Mitra, OUP, 2012, New Delhi.

Reference Books

1. Spoken English- A Manual of Speech and Phonetics by R.K.Bansal & J.B.Harrison, Orient Blackswan, 2013, New Delhi.
2. Business Correspondence and Report Writing by Prof. R.C. Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd., 2001, New Delhi.
3. Practical Communication: Process and Practice by L.U.B. Pandey; A.I.T.B.S. Publications India Ltd.; Krishan Nagar, 2014, Delhi.
4. Skills for Effective Business Communication by Michael Murphy, Harward University, U.S.
5. Business Communication for Managers by Payal Mehra, Pearson Publication, Delhi.

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Sub Code: CS524A3 Credit:3 (L-3, T-0, P-0)

Sub Name: SOCIAL NETWORK ANALYSIS

Questions to be set: 05 (All Compulsory)

Course Objectives: To understand how the world is connected -- socially, strategically and technologically and why it matters and to introduce the basic notions and model used for social network analysis.

Pre-requisites: Graph Theory

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define competence in Social Network Analysis fundamentals.
2. Explain and extend the competence in structural properties of Social Network fundamentals.
3. Illustrate the ability to formulate and interpret several Social Network models.
4. Represent the mathematical representation and analyse Social Network results.
5. Compare and analyze Social Network Data to reach a valid conclusion.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction	in class	Motivation, The Social network perspective, Different sources of network data. Social Network Analysis: Preliminaries and definitions, Erdos Number Project, Centrality measures, Balance and Homophily.	8	1,2		
	**Assignment Topics	Historical and Theoretical Foundation, Fundamental concepts of network analysis				
Module 2: Social Network Data Mathematical Representation of Social Network	in class	Definition, Boundary Specification and Sampling, Types of networks – One mode networks, Two mode networks, Ego-centered and Specific Dyadic networks, Network data, Measurement, Collection, Datasets. Notation for Social network data, Graph Theory, Sociometri Notation, Algebraic Notation, Graphs, Directed Graph, Signed graph, Valued graph, Multigraph, Hypergraph, Matrices of graph, digraph, hypergraph, Random graphs and alternative models	12	2,3		
	**Assignment Topics	Models of network growth, Navigation in social Networks.				
Module 3: Structural Properties of Networks	in class	Cohesiveness of subgroups, roles and positions, Multidimensional Scaling, Ego networks, Weak ties, Structural equivalence, Structural hole, Equitable partitions, Stochastic block models.	6	3,4		
	**Assignment Topics					

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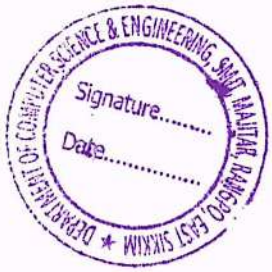
Module 4: Cascading Properties of Networks	in class	Information/influence diffusion on networks, Maximizing influence spread, Power Law and Heavy tail distributions, Preferential attachment models, Small world experiments, Small world models, Origins of small world	6	4		
	**Assignment Topics	Heavy tails, Small Diameter, Clustering of connectivity				
Module 5: Models of Network Formation Mining Graphs	in class	Erdos-Renyi Model- The Model & Threshold Phenomenon, Clustering Models – The Model, Programming Clustering, Clustering Coefficient, Preferential Model - Preferential Attachment Community and cluster detection: random walks, spectral methods;	8	5		
	**Assignment Topics	link analysis for web mining.				

Text Books:

1. S. Wasserman and K. Faust. Social Network Analysis: Methods and Applications, Cambridge University Press, 1994
2. D. Easley and J. Kleinberg, Networks, Crowds and Markets: Reasoning about a highly connected world, Cambridge University Press, 2010

Reference Books:

1. Peter R. Monge, Noshir S. Contractor, Theories of communication networks. Oxford University Press, 2003.
2. Duncan Watts. Six degrees: the science of a connected age. Norton, 2004.



Sub Code: CS525A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: PARALLEL AND DISTRIBUTED ALGORITHMS

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide you with an introduction and overview to the computational aspects of parallel and distributed computing. To introduce several important parallel computing models that capture the essence of existing and proposed types of synchronous and asynchronous parallel computers. To study typical models for distributed computing. To study a few typical algorithms for each model, selected from various basic areas such as sorting, selection, graphs, matrices, numerical problems, and computational geometry. To provide an important skill for those who may work with large applications since these usually must be implemented on a parallel or distributed system, due to their memory space and speed requirements.

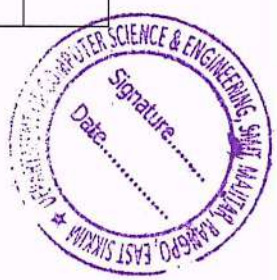
Pre-requisites: Multiprocessor systems, Design and Analysis of Algorithms, Parallel Computing. Course

Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Discuss in-depth on how to think about algorithms in a parallelized manner.
2. Select algorithms suitable for conventional, single-processor computers which are not appropriate for parallel architectures.
3. Compare inherent parallel algorithms with their counterparts.
4. Justify the choice of parallel algorithms to accomplish a task.
5. Illustrate the process of synchronization.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: The Idea of Parallelism	in class	A Parallelised version of the Sieve of Eratosthenes, PRAM Model of Parallel Computation, Pointer Jumping and Divide & Conquer:	6	1		
	**Assignment Topics	Useful Techniques for Parallelization				
Module 2: PRAM Algorithms	in class	Parallel Reduction, Prefix Sums, List Ranking, Preorder Tree Traversal, Merging Two Sorted Lists, Graph Coloring, Reducing the Number of Processors and Brent's Theorem	6	2,3		
	**Assignment Topics					
Module 3: Taxonomy of Parallel Computing Platforms	in class	Cost of Communication, The role of compilers and writing efficient serial programs, Parallel Programming Languages: Shared Memory Parallel Programming using OpenMP, Parallel Complexity: The P-Complete Class	8	3,4		



	**Assignment Topics	Programmer's view of modern multi-core processors,				
Module 4: Scheduling Dictionary Operations	in class	Mapping and Scheduling, Elementary Parallel Algorithms, Matrix Multiplication, Writing efficient openMP programs, Sorting Parallel Search, Graph Algorithms, Safety, liveness, termination,	12	4		
	**Assignment Topics	logical time and event ordering				
Module 5: gorithms and ichronization	in class	Mutual exclusion and Clock Synchronization, Distributed Graph algorithms, Distributed Memory Parallel Programming: Cover MPI programming basics with simple programs and most useful directives; Demonstrate Parallel Monte Carlo	8	5		
	**Assignment Topics	Global state and snapshot algorithms,				

Text Books:

1. Michael J Quinn, Parallel Computing, TMH
2. Joseph Jaja, An Introduction to Parallel Algorithms, Addison Wesley

Reference Books:

1. Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating Systems, TMH
2. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Pearson

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Sub Code: CS526A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: QUANTUM COMPUTING

Questions to be set: 05 (All Compulsory)

Course Objectives: Analyze the behavior of basic quantum algorithms and to Implement simple quantum algorithms and information channels in the quantum circuit model and to Simulate a simple quantum error-correcting code. Prove basic facts about quantum information channels

Pre-requisites: Familiarity with linear algebra including concepts such as vector space, inner products, matrices, eigenvalues and eigenvectors will be assumed

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Describe the fundamentals of quantum information processing.
2. Illustrate the fundamentals of quantum computation, quantum cryptography, and quantum information theory.
3. Device the quantum circuit model consisting of qubits, unitary operators, measurement, entanglement.
4. Represent various implementations of Quantum computers.
5. Explain various applications of Quantum computers in real life.

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Introduction Quantum Cryptography	in class	introduction to quantum cryptography. BB84, B92 protocols. Introduction to security proofs for these protocols	8	1		
	**Assignment Topics	Cryptography, classical cryptography,				
Module 2: Quantum Algorithm	in class	Introduction to quantum algorithms. Deutsch-Jozsa algorithm, Grover's quantum search algorithm, Simon's algorithm. Shor's quantum factorization algorithm.	8	2,3		
	**Assignment Topics					
Module 3: Error Correction	in class	Simple examples of error correcting codes in classical computation. Linear codes. Quantum error correction and simple examples. Shor code	8	3,4		
	**Assignment Topics	Errors and correction for errors				
Module 4: Quantum Entanglement	in class	Bell's inequalities, EPR paradox. Theory of quantum entanglement. Entanglement of pure bipartite states. Entanglement of mixed states. Peres partial transpose criterion. NPT and PPT states, bound entanglement, entanglement witnesses	8	4		

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	**Assignment Topics	Quantum correlations				
Module 5: Implementations	in class	NMR and ensemble quantum computing, Ion trap implementations. Optical implementations.	8	5		
	**Assignment Topics	Different implementations of quantum computers.				

Text books:

1. Quantum Computation and Quantum Information, M.A. Nielsen and I.L.Chuang, Cambridge University Press 2000.

Reference Books:

1. P. Kaye, R. Laflamme, and M. Mosca. An Introduction to Quantum Computing. Oxford, 2007.
2. M. A. Nielsen and I. L. Chuang. Quantum Computation and Quantum Information. Cambridge University Press, 2000.

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Sub Code: CS527A3 **Credit:3 (L-3, T-0, P-0)**

Sub Name: APPLICATIONS OF WEB TECHNOLOGY

Questions to be set: 05 (All Compulsory)

Course Objectives: To enable learners to understand and apply the various steps in designing a creative and dynamic website using latest web technologies

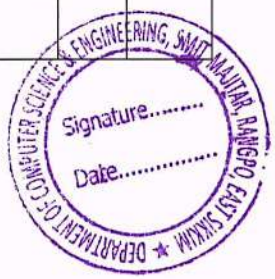
Pre-requisites: Fundamentals of Web Technologies

Course Outcomes(CO): On completion of the course it is expected to endow the students with skills to:

1. Define the basic terms of HTML, CSS and JavaScript.
2. Identify appropriate web based technologies for developing dynamic webpages.
3. Choose an appropriate database language and technologies for connecting front end to backend.
4. Distinguish major frameworks for development of web services and cloud applications.
5. Test appropriate content management system for developing scalable websites

** not more than 20% of total topics to be allotted for assignment

Module	Mode	Topics	Hrs	CO	PO	PSO
Module 1: Mark-up Language	in class	Mark-up languages, XML, Uses of XML. WELL-FORMED XML: Parsing XML, Tags, text, elements, attributes, comments and empty elements. XML Declaration, Processing Instructions XML NAMESPACES: Need for namespaces, How XML namespaces work, URIs,.	6	1		
	**Assignment Topics	Errors in XML, When to use namespace				
Module 2: Javascript	in class	Introduction, Obtaining user inputs, memory concepts, Operators, Control Structures, Looping constructs, break, continue statements, Programmer defined functions, Scoping rules, Array declaration and allocation, passing arrays to function, Objects: String, Date, Boolean, Window, document; using cookies, Handling Events Using JavaScript.	6	2,3		
	**Assignment Topics	Recursion and iteration				
Module 3: Web Optimization & SEO	in class	Web Browsers, Caching, Downloading and Rendering, Persistent Connections, DNS caching and prefetching, Buffering, Weblog Optimization and Security: Parallel Downloading, Controlling caches, Content compression, Load balancers, Tuning MYSQL, Using query caching, Search engines: Searching techniques used by search engines, keywords, Search engine optimization for individual web pages: header entries, tags, selection of URL, alt tags, Search engine optimization for entire website, Google analytics	8	3,4		
	**Assignment Topics	Optimizing query execution and optimization				



Module 4: Advanced PHP	in class	Installing and Configuring MySQL and PHP, Basic Security Guidelines, Variables, Data Types, Operators and Expressions, Constants, Flow Control Functions; Switching Flow, Loops, Form processing, Connecting to database, using cookies, dynamic contents, Validating User Input, Handling and Avoiding Errors.	12	4		
	**Assignment Topics	Code Blocks and Browser Output, Configuring email with PHP				
Module 5: Web services & Content Management System	in class	Web services, Design and modelling of web services, Introduction to Service Oriented Architecture, Combining protocols to build Web services – clarifying web services, REST Services, WS-* Web services using SOAP and WSDL, Case Study: Drupal as open source content management system –and Module development.	8	4,5		
	**Assignment Topics	REST vs WS-* services, Site building , Site configuration				
		Case Study on Applications of Web Technology.				

Text Books:

1. Deitel H.M., Deitel P.J., "Internet & World Wide Web: How to program", Pearson Education.
2. Boronczyk, Naramore, "Beginning PHP, Apache, MySQL Web Development", Wiley India Pvt. Ltd.

Reference Books:

1. Peter Smith, "Professional Website performance", Wiley India Pvt. Ltd.
2. Kogent Learning, "Web Technologies: HTML, JavaScript, PHP, Java, JSP, XML, AJAX Black Book", Wiley India Pvt. Ltd.