Syllabus for ME (Computer Engineering)
Course 2013 (w.e.f 2013)

Subject Code	Subject	Teaching Scheme Hrs/Week		Examination Scheme					Credits
		Lect.	Pract	Paper		Tw	Oral/Presentation	Marks	
				In Semester Assessment	End Semester Assessment				
SEM — I									
510101	Applied Algorithms	04	—	50	50	—	—	100	4
510102	High Performance Databases	04	—	50	50	—	—	100	4
510103	Advanced Computer Architecture	04	—	50	50	—	—	100	4
510104	Research Methodology	04	—	50	50	—	—	100	4
510105	Elective –I	05	—	50	50#	—	—	100	5
510106	Laboratory Practice-I	—	04	—		50	50	100	4
	Total	**21**	**04**	**250**	**250**	**50**	**50**	**600**	**25**

Subject Code	Subject	Teaching Scheme Hrs/Week		Examination Scheme					Credits
		Lect.	Pract	Paper		Tw	Oral/Presentation	Marks	
				In Semester Assessment	End Semester Assessment				
SEM— II									
510107	Operating System Design	04	—	50	50	—	—	100	4
510108	Software Design and Architecture	04	—	50	50	—	—	100	4

510109	**Advanced Computer Networks**	04	—	50	50	—	—	100	**4**
510110	Elective –II	05	—	50	50#	—	—	100	**5**
510111	Laboratory Practice-II	—	04	—		50	50	100	**4**
510112	Seminar-I	—	04	—		50	50	100	**4**
	Total	**17**	**08**	**200**	**200**	**100**	**100**	**600**	**25**

Subject Code	**Subject**	**Teaching Scheme Hrs/Week**		**Examination Scheme**					**Credits**
		Lect.	**Pract**	**Paper**		**Tw**	**Oral/Presentation**	**Marks**	
				In Semester Assessment	**End Semester Assessment**				
SEM— III									
610101	**Advanced Storage Systems and Infrastructure Management**	04	—	50	50	—	—	100	**4**
610102	**Advanced Unix Programming**	04	—	50	50	—	—	100	**4**
610103	Elective-III	05	—	50	50#	—	—	100	**4**
610104	Seminar –II	04	—			50	50	100	**5**
610105	Dissertation Stage – I	—	08	—		50	50	100	**8**
	Total	**17**	**08**	**150**	**150**	**100**	**100**	**500**	**25**

Subject Code	**Subject**	**Teaching Scheme Hrs/Week**		**Examination Scheme**					**Credits**
		Lect.	**Pract**	**Paper**		**Tw**	**Oral/Presentation**	**Marks**	
				In Semester Assessment	**End Semester Assessment**				

SEM— IV									
610106	Seminar –III	—	05	—	—	50	50	100	**5**
610107	Dissertation Stage – II	—	20	—	—	150	50	200	**20**
	Total		**25**	—	—	**200**	**100**	**300**	**25**

#: Ref. Rule R-1.3 for Examination Rules of *"Rules and Regulations for M.E. Programs under faculty of Engineering effective from June 2013"*.

Electives:

Elective I		Elective II	
510105A	**Intelligent Systems**	**510110A**	**Business Intelligence and Data Mining**
510105B	**IR and Web Mining**	**510110B**	**Usability Engineering**
510105C	**Machine Learning and Translation**	**510110C**	**Advanced Complier Design**
510105D	**Open Elective /Real Time Systems**	**510110D**	**Open Elective/ Embedded System Design**

Elective III		Non Credit Courses	
610103A	**Network Security**	**Semester -I**	**Cyber Security**
610103B	**Cloud Computing**	**Semester-II**	**Information and Cyber Warfare**
610103C	**Computer Vision and Pattern Recognition**	**Semester-III**	**Bio-Metrics and Cyber Security**
610103D	**Open Elective/ Soft Computing**	**Semester -IV**	**Cyber Forensics and Information Security**

The dissertation must result into the publication of at least two research papers (at Stage–I and Stage-II respectively) preferably in the Journal having Citation Index 2.0 and ISSN number; or paper can be published in reputed International Journal recommended by the guide of the Dissertation and the BoS supported cPGCON event for paper presentation and participation. The guides certificate covering originality of the work and plagiarism-testing result shall be included in the report along with the Published Journal Papers and. cPGCON paper presentation and participation certificates. The comments received by the journal paper reviewers be attached in the Dissertation report and shall be made available during dissertation presentation/viva to the examiners.

Note 1: Refer R-2.7 for Examination Rules of *"Rules and Regulations for M.E. Programs under faculty of Engineering effective from June 2013"*. Non-credit courses are mandatory for the grant of the term and shall be completed by the students as a self study either by referring to the Hand books, Journal/Conference papers (atleast 25 in number), open source software, tools and in addition may be by organizing educational visits to the technological/professional centers in the subject, *if any*. Each student is required to produce in own words, one 10 pages innovative, technical paper to be submitted as a part of the semester course work of non-credit courses.

510101- Applied Algorithms

Teaching Scheme **Examination Scheme**

Lectures: 4Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 04

Objectives

- This course covers selected topics in algorithms that have found applications in areas such as geometric modeling, graphics, robotics, vision, computer animation, etc.
- The course objective is to teach problem formulation and problem solving skills.
- The course aims at keeping a sound balance between programming and analytical problem solving.

Unit I. Analysis of Algorithms

Review of algorithmic strategies, Asymptotic analysis: upper and lower complexity bounds. Identifying differences among best, average and worst Case Behaviors. Big O, little O, omega and theta notations, Standard complexity classes. Empirical measurements of performance. Time and space trade-offs in algorithms. Analyzing recursive algorithms using recurrence relations.

Unit II. Fundamental Computing Algorithms

Numerical algorithms, Sequential and binary search algorithms. Quadratic sorting algorithms and O (n log n) sorting algorithms. Algorithms on graphs and their complexities using Greedy Approach for --- Prim's and Krushkal's Algorithm for minimum spanning tree, Single source shortest path Algorithm, all pair shortest paths in Graph

Unit III. Approximation Algorithms

Introduction, Absolute approximation, Epsilon approximation, Polynomial time Approximation schemes, probabilistically good algorithms.

Unit IV. Geometric Algorithms

Prerequisites – Basic properties of line, intersection of line, line segment, polygon,etc. Line segment properties, detaining segment intersection in time complexity (n log n),Convex full problem – formulation, solving by Graham scan algorithm, Jarvis march algorithm; closest pair of points – problem formulation, solving by divide & conquer method.

Unit V. Linear Programming

Standard and Slack forms, formulation of problems as linear programs, simplex algorithm, duality, initial basic feasible solution.

Problem formulation for – single source shortest path, maximum flow problem, Vertex cover problem, Knapsack problem.

Unit VI. Probability Based Analysis

Expectations**:** Introduction, Moments, Expectations of functions of more than one random variable, transform methods, moments and transforms of distributions, computation of mean time to failure, inequalities and limit theorems

Reference Books:

1. Kishore S. Trivedi, "Probability & Statistics with Reliability, Queing, and Computer Science Applications" PHI
2. Cormen, Leiserson, Rivest, "Algorithms", PHI
3. Bressard, "Fundamentals of Algorithms", PHI
4. Horowitz, Sahni, "Fundamentals of Computer Algorithm", Galgotia

5. S. Baase, S and A. Van Gelder, "Computer Algorithms: Introduction to Design and Analysis", 3rd edition. Addison Wesley,2000
6. Aho, Hopcraft, Ullman, “The Design and Analysis of Computer Algorithms”, Addison Wesley
7. Knuth, “Art of Programming”, Addison Wesley
8. C Papadimitriou and K Steiglitz, “Combinatorial Optimization”, PHI

510102 - High Performance Databases

Teaching Scheme
Lectures: 4 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 04

UNIT I. Physical database design & Tuning

Database workloads, physical design and tuning decisions, Need for Tuning
Index selection: Guideline for index selection, Clustering & Indexing Tools for index selection
Database Tuning: Tuning indexes, Tuning Conceptual schema Tuning Queries &views, Impact of Concurrency, Benchmarking

UNIT II. Distributed Databases

Introduction, Design Framework, Design of database fragmentation, The Allocation of Fragments, Translation of global queries to fragment queries, Optimization of access queries, Distributed Transaction Management, Concurrency Control, Reliability.

UNIT III. Advance Transaction Processing

Transaction Processing Monitors, Transactional Workflow, Real time transaction System, Long duration Transactions, Transaction Management in Multi-databases, Distributed Transaction Management, Main Memory Databases, and Advanced Transaction Models.

UNIT IV. Semi-Structured Data and XML

Semi-Structured Data, Introduction to XML, XML hierarchical Model, DTD & XML schema, XML Namespace, XML query & Transformation: Xpath, XSLT, XQuery, Storage of XML data, **XMLTechnologies :** DOM &SAX Interfaces X pointer, Xlink, XHTML, SOAP, WSDL, UDDI,XML database Application.

UNIT V. Emerging Trends in Databases

Introduction, Motivation, Temporal databases, Spatial & geographic databases, Multimedia Databases, Mobility & personal Databases

UNIT VI. Advanced Application Development

Performance Tuning, Performance Benchmarks, Standardization, E-Commerce, Legacy Systems, Large-scale Data Management with HADOOP, Semi structured database COUCHDB: Introduction, Architecture and principles, features

References:

- Database system Concept by Silberschatz And Korth 6th Edition
- Distributed Databases principles & systems by Stefano Ceri, Giuseppe Pelagatti
- Web Data Management, Abiteboul, Loana, Philippe Et. al Cambridge publication
- Database Systems, Thomas Connolly, Carolyn Begg, Pearson 4th Edition
- Database Management Systems by Raghu Ramakrishnan and Johannes Gehrke

510103- Advanced Computer Architecture

Teaching Scheme **Examination Scheme**

Lectures: 4 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 04

Unit – I Introduction to architectures and Computing Models

Evolution in processor development, Generic computer architecture, Data representation, Instruction sets, data path and control, memory management, Buses and peripherals, Networking and communication, Multiprocessor and multicomputer, multivector and SIMD systems, PRAM and VLSI models, network properties, conditions for parallelisms, partitioning and scheduling, program flow mechanisms, system interconnect architectures

Unit –II Performance metrics

Metrics and measures for parallel programs, Speedup performance laws, scalability analysis approaches, Amdahl's law, limitation, Benchmark, SIMD, MIMD Performance.

Unit – III Hardware parallelism

Processor and memory hierarchy- Advanced processor technology, superscalar and vector processors, memory hierarchy, virtual memory, shared memory organizations, bus systems, consistency on shared data, Pipelining- Linear and non linear pipelines, Instruction pipelines, instruction and arithmetic pipeline design

Unit – IV Parallel and Scalable architectures

Multiprocessor and system interconnects, cache coherence and synchronization mechanisms, multicomputer generations, message passing paradigms, Multivector architecture-principles of vector processing, multivector multiprocessors, compound vector processing, SIMD organization, MIMD organization, multithread and dataflow architectures: Multithreading, fine grained multicomputers, dataflow and hybrid architectures, Single Program-Multiple Data(SPMD), Multiple Program, Multiple Data(MPMD), Case study of non-coherent multiprogramming in PRAM

Unit – V Parallel programming and program development environments

Parallel programming models, parallel languages and compilers, dependence analysis and of data arrays, code optimization and scheduling, loop parallelism and pipelining, Parallel programming environments, synchronization and multiprocessing modes, shared variable programs, message passing programs, mapping programs on multi-computers.

Operating system support for parallel program execution, processes and threads, parallel programming languages-C-Linda, Fortran-90, Programming with MPI. Introduction to map-reduce.

Unit – VI Advanced Computing Architectures

Quantum Computing, Bio/Molecular Computing, Grid Computing, Neuro Computing, Cloud Computing, Introduction to GPU parallel architecture.

Reference Books:

1. Computer Architecture and Organization, Miles Murdocca, Vincent Heuring- Wiley Publication
2. Advanced Computer Architecture, Kai Hwang and Naresh Jotwani, Mc. Graw. Hill Publication
3. High Performance Computer Architectures by Harrold Stone
4. Computer Architecture: A Quantitative Approach, John L Hennessy, David a Patterns, 4th Edition, Elsevier, ISBN: 976-61-312-0721-0

510104- Research Methodology

Teaching Scheme **Examination Scheme**

Lectures: 4 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 04

- Objective: to introduce the student to research methodology, and to prepare them for conduct independent research

Unit I. Understand the research process

Evolution of research methodology; Meaning, nature, scope, and significance of research; Research paradigm; Objectives of research, Motivation for research; Postulates underlying scientific investigations; Types of research; Research process and workflow; Principles of ethics, ethical considerations in research; Intellectual Property Rights (IPR)

Unit II. Problem identification and hypothesis formulation

Selecting an area for research; Problem identification; Literature search; "Understanding" reported research; Fitting the pieces; Ascertaining current state of knowledge; Sources of information; Recording literature search findings; Defining the problem; Hypothesis formulation

Unit III. Research design

Type of research designs, pitfalls and advantages; Research approaches; Principles of experimental design; Design of experiments; Characteristics of good research design; Universe, population, and sample; Sampling concepts, principles, and techniques; Sample design (random, pseudo random, cluster, stratified, multi-stage); Sampling considerations (size, design, selection, measurements); Measures, Measurements, Metrics, and Indicators; Measurement scales and direct measurements

Unit IV. Methods, tools, and techniques

Data collection techniques (observation, interviewing, questionnaires, web-based, group techniques, experimentation, surveys); Sources of errors; Reliability and validity; Probability theory and theoretical distributions; Parametric statistics, Simple linear models (ANOVA, correlation and Regression, ANACOVA), Multivariate analysis, Step-wise regression; Non-parametric statistics, Sign test, Paired ranking test, Pearson Correlation, Man-Whitney U Test, Chi-square test,

Unit V. Data processing and Data analysis

Primary and secondary data; coding and summarization of data, quantification of qualitative data (content analysis); Computation of indirect metrics; Role of descriptive statistics; Measures of central tendency, dispersion, skewness, kurtosis; plots and correlations; Inferential statistics, hypothesis testing, Type I and Type II errors, Power of tests; Role of computers in research; Use of statistical packages (e.g. SPSS)

Unit VI. Reporting research

Dissemination of research findings; Reporting and interpretation of results; cautions in interpretations, Type of reports, Typical report outlines, use of diagrams, tables, and charts; Optimization and optimization methods, Introduction to game theory, Queuing theory

References:

1. Kothari C.R., Research Methodology (2nd Ed.), New Age International, (2004); ISBN(13): 978-81-224-1522-3
2. Kumar, Ranjit, Research Methodology (3rd Ed); Sage Publications, 2011; IBSN: 978-1-8492-0301-2
3. Berkman, Elliot T., A Conceptual Guide to Statistics Using SPSS, Sage Publications, 2011; ISBN: 978-1-4129-7406-6

ELECTIVE-I

510105A- Intelligent Systems

Teaching Scheme **Examination Scheme**

Lectures: 5 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 05

1. Introduction

Intelligent Agents: Introduction. Agents and Environments, Good Behavior: The Concept of Rationality, The Nature of Environments, The Structure of Agents.

Problem Formulation: Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Avoiding Repeated States, Searching with Partial Information.

2. Search Methods

Informed Search and Exploration: Informed (Heuristic) Search Strategies, Heuristic Functions, Local Search Algorithms and Optimization Problems, Local Search in Continuous Spaces, Online Search Agents and Unknown Environments, Generic Algorithms for TSP.

Constraint Satisfaction Problems: Constraint Satisfaction Problems, Backtracking Search for CSPs, Local Search for Constraint Satisfaction Problems, Structure of Problems.

3. Planning

The Planning Problem, Planning with State-Space Search, Partial-Order Planning, Planning Graphs, Planning with Prepositional Logic, Analysis of Planning Approaches.

4. Planning and Acting in the Real World

Time, Schedules and Resources, Hierarchical Task Network Planning, Planning and Acting in Nondeterministic Domains, Conditional Planning, Execution Monitoring and Re-planning, Continuous Planning, Multi-Agent Planning.

5. Uncertain knowledge and reasoning

Acting under Uncertainty, Basic Probability Notation, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distributions, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks, Extending Probability to First-Order Representations, Other Approaches to Uncertain Reasoning.

6. Making Simple &Complex Decisions

Combining Beliefs and Desires under Uncertainty, The Basis of Utility Theory, Utility Functions, Multi-attribute Utility Functions, Decision Networks, The Value of Information, Decision-Theoretic Expert Systems, Sequential Decision Problems, Value Iteration, Policy Iteration.

Reference Books:

1. Stuart Russell, Peter Norvig, “Artificial Intelligence – A Modern Approach” 2nd Edition Pearson Publication, ISBN No.978-81-775-8367-0.

2. Patrick Henry Winston, “Artificial Intelligence”, 3rd Edition.,Pearson Publication, ISBN No. 978-81-317-1505-5.

3. Patrick Henry Winston., “Lisp programming language”, Pearson Publication.

510105B- IR and WEB Mining

Teaching Scheme **Examination Scheme**

Lectures: 5 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 05

Unit I. Information Retrieval Basics

Goals and history of IR. The impact of the web on IR. Components of an IR system, Boolean and vector-space retrieval models; ranked retrieval; text-similarity metrics; TF-IDF (term frequency/inverse document frequency) weighting; cosine similarity. Simple tokenizing, stop-word removal, and stemming; inverted indices, Index Construction and compression.

Unit II. Information Retrieval Models

Probabilistic Information Retrieval, Language Modeling for Information Retrieval, Adhoc Retrieval, Latent Semantic Indexing, Relevance feedback, Pseudo relevance feedback, Query expansion, Query languages, POS tagging,

Unit III. Web Mining

Web Structure, content and usage mining, Web Crawling, Indexes, Search engines; spidering; metacrawlers; directed spidering; link analysis (e.g. hubs and authorities, Google PageRank), Information Extraction, spam filtering, XML retrieval.

Unit IV. Performance metrics

Recall, precision, and F-measure; Evaluations on benchmark text collections, TREC Tracks. Social Networks : Social Web, Blogs, Wikis, Forums, Social Network analysis, Recommender systems, Information Filtering, Collaborative filtering and content-based recommendation of documents and products.

Unit V. Semantic web

Web 3.0, Ontology, OWL, RDF Schema, ontology learning, Knowledge representation, management and extraction, Multimedia Retrieval, Content based Image retrieval, Pattern Matching and classification for IR.

Unit VI. Specific topics in IR and Web Mining

Focused Retrieval, Transfer Learning, Learning to Rank, Personalisation, Behavioral Targeting, Cross Language IR, Digital Libraries, Bibliographic systems, Patent Search, E-learning, Security Issues,Political and ethical issues.

References :

1. Yates & Neto, "Modern Information Retrieval", Pearson Education, ISBN 81-297-0274-6 (2011).
2. *Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze* , “Introduction to Information Retrieval” (available online at http://nlp.stanford.edu/IR-book/)
3. Chakrabarti, S., Mining the Web, Morgan Kaufmann (An Imprint of Elsevier) 2005.

Additional References :

1. C.J. Rijsbergen, "Information Retrieval", (http://www.dcs.gla.ac.uk/Keith/Preface.html)
2. Grossman, D. A. and Frieder, O., Information Retrieval: Algorithms and Heuristics. Kluwer 1998.
3. Search Engines: Information Retrieval in Practice by Bruce Croft, Donald Metzler, and Trevor Strohman, Addison-Wesley, 2009.
4. Information Retrieval: Implementing and Evaluating Search Engines by S. Buttcher, C. Clarke and G. Cormack, MIT Press, 2010.
5. Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data by B. Liu, Springer, Second Edition, 2011.

510105C- Machine Learning and Translation

Teaching Scheme **Examination Scheme**

Lectures: 5 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 05

Unit I. Introduction to Machine Learning

Introduction to ML, Introduction to Statistical Learning Methods, History of Machine Learning, Machine-Learning Problem, Learning Paradigms, Machine-Learning Techniques and Paradigms, Need of Learning, Machine Intelligence

Unit II. Learning theory : Supervised learning and Unsupervised learning.

Logistic regression, Simple Neural Network, Perceptron, Generative learning algorithms. Gaussian discriminant analysis. Naive Bayes. Support vector machines. Model selection and feature selection. Ensemble methods: Bagging, boosting. Evaluating and debugging learning algorithms. VC dimension. Worst case (online) learning. Practical advice on how to use learning algorithms. Measuring Learning Performance, Learning and Knowledge building**,** Clustering. K-means. EM. Mixture of Gaussians. Factor analysis. PCA (Principal components analysis). ICA (Independent components analysis).

Unit III. Fundamentals of Whole-System, Systemic, and Multi-perspective Machine Learning

Systemic Machine Learning, Machine-Learning Framework, Multi-perspective Decision Making and Multiperspective Learning, Dynamic and Interactive Decision Making, The Systemic Learning Framework, System Analysis

Unit IV. Reinforcement Learning

Learning Agents, Returns and Reward Calculations, Reinforcement Learning and Adaptive Control, Dynamic Systems, Reinforcement Learning and Control, Markov Property and Markov Decision Process, Value Functions, Action and Value, Learning an Optimal Policy (Model-Based and Model-Free Methods), Dynamic Programming, Adaptive Dynamic Programming, Example: Reinforcement Learning for Boxing Trainer

Unit V. Machine Learning Models and Inference

A Framework for Learning, Capturing the Systemic View for learning, Mathematical Representation of System Interactions, Impact Function, Decision-Impact Analysis. Inference Mechanisms and Need, Integration of Context and Inference, Statistical Inference and Induction, Pure Likelihood Approach, Applying Bayesian Paradigm and Inference, Time-Based Inference, Inference to Build a System View, Applying Bayesian Learning, Applying SVM, Applying Gaussian maximum likelihood

Unit VI. Adaptive and Incremental Machine Learning

Adaptive Learning and Adaptive Systems, Adaptive Machine Learning, Adaptation and Learning Method Selection Based on Scenario, Applications of Adaptive Learning, Competitive Learning and Adaptive Learning, Incremental Learning, Learning from What Is Already Learned, Supervised Incremental Learning, Incremental Unsupervised Learning and Incremental Clustering, Semi-supervised Incremental Learning, Incremental and Systemic Learning, Incremental Closeness Value and Learning Method, Learning and Decision-Making Model, Incremental Classification Techniques

Unit VII. Knowledge Representation and Augmentation: A Machine Learning Perspective

Knowledge Augmentation and Knowledge Elicitation, Life Cycle of Knowledge, Incremental Knowledge Representation, Case-Based Learning and Learning with Reference to Knowledge Loss, Knowledge Augmentation: Techniques and Methods

Heuristic Learning , Systemic Machine Learning and Knowledge Augmentation, Knowledge Augmentation in Complex Learning Scenarios

Unit VIII. Building a Learning System

Systemic Learning System, Algorithm Selection, Knowledge Representation, Designing a Learning System, Making System to Behave Intelligently, Example-Based Learning. Holistic Knowledge Framework and Use of Reinforcement Learning, Intelligent Agents—Deployment and Knowledge Acquisition and Reuse, Case-Based Learning: Human Emotion-Detection System, Holistic View in Complex Decision Problem, Knowledge Representation and Data Discovery

References :

1. Reinforcement and Systemic Machine Learning for Decision Making, Parag Kulkarni, July 2012, Wiley-IEEE Press, ISBN: 978-0-470-91999-6
2. Introduction to Machine Learning, Ethem ALPAYDIN, The MIT Press, October 2004, ISBN 0-262-01211-1
3. Machine Learning, Tom Mitchell, McGraw Hill, 1997.
4. The Elements of Statistical Learning: Data Mining, Trevor Hastie, Robert Tibshirani, Jerome Friedman, Inference, and Prediction, Second Edition, February 2009

510105D- Real Time Systems

Teaching Scheme
Lectures: 5 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 05

Unit I. Introduction

Issues in Real-Time Computing, Structures of Real-Time System, Task Classes, Performance Measures for Real-Time Systems, Estimating Program Run Times

Unit II. Task Assignment and Scheduling

Classical Uni-processor Scheduling algorithm, Uni-processor Scheduling of IRIS Tasks, Task Assignment, Mode Changes, Fault Tolerant Scheduling

Unit III. Programming Languages and Tools

Desired Language characteristics, Data Typing , Control Structures , Facilitating Hierarchical Decomposition, Packages, Runtime Error (Exception) Handling, Overloading and Generics, Multitasking ,Low-Level Programming, Task Scheduling, Timing Specifications, Some experimental Languages, Programming Environments, Run-Time Support.

Unit IV. Real-Time Databases

Basic Definitions, Real-Time Vs General-Purpose Databases, Main Memory Databases, Transaction Priorities, Transaction Aborts, Concurrency Control Issues, Disk Scheduling algorithm, A Two Phase Approach To Improve Predictability, Maintain Serialization Consistency, Databases for Hard Real Time Systems.

Unit V. Real-Time Communication

Network Topologies ,Protocols ,Clocks , A Non Fault Tolerant Synchronization Algorithm, Impact of Faults , Fault Tolerant Synchronization in Hardware, Synchronization in Software

Unit VI. Fault Tolerant Techniques

Fault Types , Fault Detection, Fault and error Containment, Redundancy, Data Diversity, Reversal Checks, Malicious or Byzantine Failures, Integrated Failure Handing, Obtaining Parameter Values, Reliability Models for Hardware Redundancy, Software Error models, Taking Time into Account.

References:

1. C.M. Krishna, Kang G. Shin, “Real-Time Systems”, Tata McGraw Hill

510106- Laboratory Practice- I

Teaching Scheme
Practical: 4 Hrs/week

Examination Scheme
OR: 50 Marks
TW: 50 Marks
Total Credits : 04

1. Develop algorithmic solution for solving the problem stated in assignment 2, 3 below using set theory, Probability theory and/or required theories, strategy to design Turing machine, multiplexer logic inducing concurrency and perform NP-Hard analysis for the solution feasibility.
2. Design and implement the distributed architecture for the Hadoop having Name node, Tracker node and data nodes (separated by ADSL routers) or such recent technology. Prepare architecture diagram and installation document to be used for the assignment number 3
3. Implement Digital Library Infrastructure using Hadoop or Similar recent technology for distributed database storage. To develop front end GUI and algorithm for searching the multimedia resource files, presentations in the selected domain, author, book title, ISBN.. Use different search exploration techniques.

Or Assignments equivalent to above assignments.

4. Elective teacher shall design four suitable assignments based on Elective I maintaining above quality of the assignments.
5. Design and implement class/classes using latest 64-bit C++/JAVA/ Python/QT 5.1 and above, Cuda C++ or such latest 64-bit programming tools for the implementation of Two journal (IEEE Transactions/ACM Elsevier/Springer) papers published in the current year related to the respective elective subjects. Development Tools such as MATLAB/OPENCV/OPENMP/NS3 or equivalent may be used if required to interface the developed classes to the simulators.

Tools for the Laboratories: The laboratories must be equipped with adequate, well maintained working resources as per the software/equipment/tools list published by the Board of Studies time to time. For maintaining the quality and effective performance the Board of Studies may publish the quality guidelines for effective conduct of the laboratories, seminars and dissertation.

Semester - II

510107- Operating System Design

Teaching Scheme
Lectures: 4 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 04

Unit I. Introduction

System levels, Hardware Resources, Resource management, Virtual Computers, The Hardware Interface, The CPU, Memory and Addressing, Interrupts, I/O Devices, The Operating System Interface, Information and Meta-Information, Naming Operating System Objects, Device as Files, The process Concept, Communication between Processes, UNIX-Style Process Creation, Standard Input and Standard Output, The User Interface to an Operating

Design Techniques: Operating Systems and Design, Design Problems, Design Techniques, Two Level Implementation, Interface Design, Connection in Protocols, Interactive and Programming Interfaces, Decomposition Patterns.

Unit II. Implementing Processes

Implementation of a Simple Operating System, Implementation of Processes, System Initialization, Process Switching, System Call Interrupt Handling, Program Error Interrupts, Disk Driver Subsystem, Implementation of Waiting, Flow of Control Through the Operating System, Signaling in an Operating System, Interrupts in the Operating System, Operating Systems as Event and Table Managers, Process Implementation, Examples of Process Implementation, Mono-programming, Parallel System.

Unit III. Inter process Communication Patterns

Patterns of Inter process communication, New message-passing system calls, IPC Patterns, Failure of Processes, Processes: Everyday Scheduling, Preemptive Scheduling Methods, Policy versus Mechanism in Scheduling, Scheduling in Real Operating Systems, Deadlock, Two Phase Locking, Starvation, Synchronization, Semaphores, Programming Language Based Synchronization Primitives, Message Passing Design Issues

Design Techniques: Indirection, Using State Machines, Win Big Then Give Some Back, Separation of Concepts, Reducing a Problem to a Special Case, Reentrant Programs, Using Models for Inspiration, Adding a New Facility To a System.

Unit IV. Memory Management

Levels of Memory Management, Linking and Loading a Process, Variations in Program Loading, The Memory Management Design Problem, Dynamic Memory Allocation, Keeping Track of the Blocks, Multiprogramming Issues, Memory Protection, Memory Management System Calls, Virtual Memory, Virtual Memory Systems

Design Techniques: Multiplexing, Late binding, Static Versus Dynamic, Space-Time Tradeoffs, Simple Analytic Models

Unit V. I/O Devices & File Systems

I/O Devices, I/O Systems, The File Abstraction, File Naming, File System Objects and Operations, File System Implementation, File Systems Organization

Design Techniques: Caching, Optimization and Hints, Hierarchical Names, Naming of Objects, Unification of Concepts.

Unit VI. Resource Management

Issues, Types of Resources, Integrated Scheduling, Queuing Models of Scheduling, Real-time Operating Systems, Protection of Resources, User Authentication, Mechanisms for Protecting Hardware Resources, Representation of Protection Information, Mechanisms For Software Protection, The Use of Cryptography in Computer Security, The Client Server Model

References:

1. Charles Crowley, " Operating System: A Design-Oriented Approach", Tata McGraw-Hill.

510108- Software Design and Architecture

Teaching Scheme	Examination Scheme
Lectures: 4 Hrs/week	**Theory In-semester Assessment: 50 Marks**
	Theory End-semester Assessment: 50 Marks
	Total Credits : 04

Unit I. Software Design Process

Role of Software Design**:** Software design process, nature of design process, design qualities; Transferring Design Knowledge: describe design solution, transferring design knowledge, design notations, design strategies,

Unit II. Object Oriented Design

Creational, Structural, behavioural design patterns, Component based design, Formal Approach to design

Unit III. Introduction to Software Architecture

What Is Software Architecture? Why Is Software Architecture Important? Quality Attributes, Architecture and Requirements, Designing an Architecture, Documenting software Architecture, Architecture and Software Product lines

Unit IV. Software Architecture Design

Designing, Describing, and Using Software Architecture, IS2000: The Advanced Imaging Solution, Global Analysis, Conceptual Architecture View, Module Architecture View, Styles of the Module Viewtype, Execution Architecture View, Code Architecture View. Component-and-Connector Viewtype, Styles of Component-and-Connector Viewtype, Allocation Viewtype and Styles.

Unit V. Archetype Patterns

Archetypes and Archetype Patterns, Model Driven Architecture with Archetype Patterns. Literate Modeling, Archetype Pattern. , Customer Relationship Management (CRM)
Archetype Pattern, Product Archetype Pattern, Quantity Archetype Pattern, Rule
Archetype pattern.

Unit VI. Software Architectures

Object-Oriented Paradigm, Data Flow Architectures, Data-Centered Software Architecture, Hierarchical Architecture, Interaction-Oriented Software Architectures, Distributed Architecture, Component-Based Software Architecture, Heterogeneous Architecture, Architecture of User Interfaces, Implicit asynchronous communication software architecture.

Reference Books:

1. David Budgen, “Software Design”, 2nd edition, Pearson Education (LPE)
2. Software Design: From Programming to Architecture Eric J. Braude ISBN: 978-0-471-20459-6
3. Software Architecture in Practice, 3rd Edition By Len Bass, Paul Clements, Rick Kazman Published Sep 25, 2012 by Addison-Wesley Professional
4. Applied Software Architecture ,Christine Hofmeister, Robert Nord, Deli Soni, Addison-Wesley Professional; 1st edition (November 4, 1999) ,ISBN-10: 0201325713 , ISBN-13: 978-0201325713
5. Enterprise Patterns and MDA: Building Better Software with Archetype Patterns and UMLJim Arlow, Ila Neustadt ,Addison-Wesley Professional, 2004, ISBN-10: 032111230X ISBN-13: 9780321112309
6. Kai Qian, Xiang Fu, Lixin Tao, “Software Architecture and Design Illuminated”, Jones & Bartlett Learning, 2009, ISBN 076375420X, 9780763754204

510109- Advanced Computer Networks

Teaching Scheme **Examination Scheme**

Lectures: 4 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 04

Unit I

Introduction: Types of Networks. Network design issues. Network design tools, advanced network architectures. Reliable data delivery, Routing and forwarding, resource allocation, Mobility, Networked applications, Data in support of network design, General Principles of Network Design, network characteristics.

Unit II

Delay Models in Data Networks: Modeling and Performance evaluation. Multiplexing of Traffic on a Communication Link, Queuing Models- Little's Theorem, Probabilistic Form of Little's Theorem, Application of Little's Theorem, Queuing Systems: M/M/1, M/M/2, M/M/m, M/M/∞, M/M/m/m, M/M/m/q, M/M/1/N, D/D/1, M/G/1 System, M/G/1 Queues with Vacations, Reservations and Polling, Priority Queuing

Unit III

Modeling Networks as Graphs, Problems & algorithms: Multipoint line topology- CMST, Esau-William's Algorithm, Sharma's Algorithm, Bin Packing algorithms. Terminal Assignment- Greedy algorithm and exchange algorithms, Concentrator location- COM, Add, Drop, Relaxation algorithm. Network of queues, Open, closed and semi-open queues, Network node, Kleinrock's Independent approximation.

Unit IV

Quality of Service in Networks: Application and QoS, QoS mechanisms, Queue management Algorithms, Feedback, Resource reservations, traffic engineering, Ubiquitous Computing: Applications and Requirements, Smart Devices and Services, Smart Mobiles, Cards and Device Networks.

Unit V

IP packet format, IP routing method, routing using masks, fragmentation of IP packet, IPv6, advanced features of IP routers: filtering, IP QoS, NAT, routers

Unit VI

Advanced topics in computer networks: Wireless and sensor networks, multimedia networking, content distribution networks, computer network simulation, Domain-specific networks, Next generation networks, Cyber physical systems.

References:

1. Kershenbaum A., "Telecommunication Network Design Algorithms", Tata McGraw Hill
2. Simulation Modeling and analysis, Averill M. Law, W. D. Kelton
3. Computer Networks, Priciples, Technologies and Protocols for network design Natalia Olifer, Victor Olifer, Wiley India
4. Ubiquitous Computing, Stefan Poslad, WILEY INDIA EDITION

Elective – II

510110A - Business Intelligence and Data Mining

Teaching Scheme	**Examination Scheme**
Lectures: 5 Hrs/week	**Theory In-semester Assessment: 50 Marks**
	Theory End-semester Assessment: 50 Marks
	Total Credits : 05

Unit I. Introduction to Business Intelligence

Introduction to Data Information and knowledge, Data Decision Challenge, Operational vs Information Data, Introduction to Decision Support System, Introduction to Business Intelligence, Business Intelligent System Components, Business Models, Introduction to Data Warehouse, A Business analysis framework for DW.

Unit II. Data Warehouse

Introduction, Data warehouse modeling, Data warehouse design, Data warehouse technology, Distributed Data warehouse, index techniques, materialized view.

Unit III. Data Preprocessing and Cube Technology

Introduction to Data Preprocessing, Data Cleaning, Data integration, data reduction, transformation and Data Descritization.
Introduction to OLAP, Data Cube : A multidimensional model, data cube computation, data cube computation methods : multidimensional data analysis.

Unit IV. Mining Frequent Patterns and Association Rule

Introduction to association rule, market basket analysis, frequent item set, apriori algorithm, parameter, a pattern growth approach, mining closed and max patterns, pattern evaluation, pattern mining in multilevel, multidimensional data space, pattern exploration and application.

Unit V. Classification

Basic concepts, decision tree, rule based classification, Bayesian belief networks, classification by back propagation, support vector machines, lazy learners – k-NN classifier, case based reasoning , model evaluation and selection , techniques to improve classification accuracy, multiclass classification, semi-supervised classification, ensemble methods.

Unit VI. Clustering Analysis

Cluster analysis, Partitioning methods, hierarchical methods, density based methods, grid based methods, clustering graph and network data, clustering with constrains, evaluation of clustering outliers and analysis, outlier detection methods, scalable clustering algorithms.

References:

1. Data mining concepts and techniques, Jawai Han, Michelline Kamber, Jiran Pie, Morgan Kaufmann Publishers, 3rd Edition.
2. Introduction to Data Mining, Vipin Kumar, Pang-Ning Tan , Pearson
3. Building the Data Warehouse, William H Inmon, Wiley Publication 4th Edition.
4. Introduction to Business Intelligence & Data Warehousing, IBM, PHI.
5. Business modeling and Data Mining Dorian Pyle, Elsevier Publication MK.
6. Database Systems, Thomas Connolly, Carolyn Begg, Pearson 4th Edition.

510110B - Usability Engineering

Teaching Scheme	Examination Scheme
Lectures: 5 Hrs/week	**Theory In-semester Assessment: 50 Marks**
	Theory End-semester Assessment: 50 Marks
	Total Credits : 05

Unit I. Introduction to Human-Computer Interaction as an emerging field

Disciplines contributing to HCI, Human Information Processing Psychology of everyday things, Importance of human factors in design – cultural , emotional , technological, business, Need Satisfaction curve of technology, Levels of human computer interaction

Unit II. Foundations of User Interface Design (U.I.D)

Goals of UID, Goal directed Design, User Interface Models, Understanding and Conceptualizing Interface, Psychology of users designing for collaboration and communication, Process of Interaction Design, Standards & Guidelines, Usability Testing, GIU

Unit III. Human Factors

The importance of User Interface – UI and Software Designer – Goals of UI design – Motivations for human factors in Design – Understanding user needs and requirements.

Unit IV.Models

Theories – Different models - Object - Action Interface Model - Principles for Design – Data display and entry guidelines.

Unit V. Design Process

User Interface Design Process – Classes of UI design – Principles of good design – Evaluating design using the principles – Choice of color – Task oriented approach for UI - Case study.

GUI design process - Design of icons – Use of metaphors – GUI style guides and toolkits – Portability – GUI design and object oriented approach – Case study.

Unit VI. Usability

The viewpoint of user, customer and designer –Usability specification – Description of stages in usability specification and evaluation.

Information Related: Information Search and Visualization – Hypermedia and WWW. HCI Standards**:** ECMA – ISO – BSI guide.

References:

1. Linda Mcaulay, “HCI for Software Designers”,International Thompson Computer Press, USA,1998.
2. Ben Schneiderman, "Designing the User Interface", Pearson Education, New Delhi,2005.
3. Alan Cooper, "The Essentials of User Interface Design", IDG Books, New Delhi,1995.
4. Jacob Nielsen, "Usability Engineering", Academic Press, 1993.
5. Alan Dix et al, "Human - Computer Interaction", Prentice Hall, USA,1993.
6. Elements of User Interface Design - Theo Mandel, John Wiley & Sons
7. Interaction Design – Preece, Roger, Sharp, John Wiley & Sons
8. Object Modeling & User Interface Design - Mark Hamelen

510110C - Advanced Compiler Design

Teaching Scheme	Examination Scheme
Lectures: 5 Hrs/week	Theory In-semester Assessment: 50 Marks
	Theory End-semester Assessment: 50 Marks
	Total Credits : 05

Unit I. Introduction

Notation and Concepts for Languages and Grammars, Traditional compilers, structure of compiler, architecture, properties, portability and re-targetability, optimization, grammars, Closure algorithms, abstract syntax tree: lexical structure, syntax.

Unit II. Attribute grammars

Dependency graphs, attribute evaluation, cycle handling, attribute allocation, multi-visit attribute grammars, types of attribute grammars, L-attribute grammar, S-attributed grammars, equivalence of L-attributed and S-attributed grammars, Extended grammar notations and attribute grammars, manual methods.

Unit III. Intermediate code processing

Interpretation, Code generation, Assembler design issues, linker design issues. Memory Management: data allocation with explicit de-allocation, data allocation with implicit de-allocation, Static, Dynamic and Heap Storage allocation.

Unit IV

Context handling, source language data representations, routines and their activation, Code generation for control flow assessment, Code generation for modules. Examples of Parser generators, machine-independent Code generation.

Unit V. Functional & Logic Programs

Offside rules, Lists, List comprehensions, pattern matching, polymorphic typing, referential transparency, High-order functions, lazy evaluation, compiling functional languages, polymorphic type checking, Desugaring, Graph reduction, Code generation for functional, core programs, Optimizing the functional Core, Advanced graph manipulations

The logic programming models, implementation model interpretation, unification, implementation model compilation, compiled code for unification.

Unit VI. Parallel programming

Parallel programming models, processes and threads, shared variables, message passing, parallel object -oriented languages, Tuple space, automatic parallelization. Case study of simple object-oriented compiler/interpreter.

Reference Books

1. Modern Compiler Design, Dick Grune, Henri E Bal, Jacobs, Langendoen Wiley India Pvt Ltd, ISBN: 81-265-0418-8
2. The Theory and Practice of Compiler Writing, Trembley Sorenson, MacGrawHill India ISBN:0-07-Y66616-4

510110D - Embedded Systems Design

Teaching Scheme
Lectures: 5 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 04

Unit I

Introduction to Embedded systems, building blocks, legacy Embedded processors, Integrated RISC processors, DSP Processors Architecture, Selection of Processor,, LPC2148- Architecture, Register set, Programmers Model,

Unit II

Memory Systems, DRAM Technology, Video RAM, SRAM: Pseudo-Static RAM, Battery Backup SRAM, EPROM and OTP, Parity, Error Detection and Correcting Memory, Access times, Packages, DRAM Interfaces, DRAM Refresh Techniques, Optimizing line length and cache size, Logical versus physical caches, Unified versus Harvard caches, Cache coherency: Write through, write back, no caching of write cycles, write buffer, Bus snooping, MESI Protocol, MEI Protocol, BIG and Little Endian, Dual Port and Shared Memory, Bank Switching, Memory Overlays, Shadowing, Memory Interfacing, HY27UU088G5M-Architecture, Register Set, Programmers Model

Unit III

Basic Peripherals: Parallel ports, Timer Counters, 8253, MC68230 modes, Timer Processors, Real-time clocks, Serial Ports, serial peripheral interface, I^2C bus, M-Bus, RS232C, USB2.0, UART implementations, DMA Controllers, DMA Controller Models, Channels and Control Blocks, Sharing Bus Bandwidth, DMA Implementations, Intel82801 IO Controller HUB
Analogue to Digital Conversion, Sample Rate and Size, Codecs, Power Control

Unit IV

Interrupts and Exceptions, Interrupt Structure, Recognizing an Interrupt, Interrupt mechanism, MC68000 Interrupts, RISC Exceptions, Fast Interrupts, Interrupt Controllers, Instruction restart and continuation, Interrupt Latency, Interrupt Handling Do's and Don'ts, Intel i7 interrupts and programmers model

Unit V

Real-Time Operating Systems, Operating systems internals, Multitasking OS, Scheduler Algorithms, Priority Inversion, Tasks, Threads and processes, Exceptions, Memory Models, Memory Models and Address Translation, Commercial Operating Systems, Resource Protection, Linux, Disk Partitioning, Writing software for Embedded Systems: The Compilation Process, Native verses cross compilers, Run-Time Libraries, Writing Library, Using Alternative Libraries, Using Standard Libraries, Porting Kernels, C extensions for Embedded Systems, Downloading,
Emulation and Debugging techniques, The role of the development system, Emulation Techniques.

Unit VI

Buffering and other data Structures, buffers, Linear buffers, Directional Buffers, Double Buffering, Buffer Exchange, Linked list, FIFO, Circular buffers, buffer under run and over run, Allocating buffer memory, Memory leakage, effects of memory wait state scenarios, Making the right decisions, Software Benchmark Examples, Creating Software State mechanisms, Design of Burglar alarm system, Digital echo Unit, Choosing the software environment, Deriving realtime systems performance form non-real-time systems, Scheduling the data sampling, sampling the data, Controlling from an external Switch, Problems.

References

1. **Embedded Systems Design, Steve Heath, EDN Series for Design Engineers, Elsevier ISBN: 978-81-8147-970-9**
2. **Philips LPC2148 Datasheet (lpc2141_42_44_46_48_4.pdf)**
3. **HY27UU0**G5M.pdf**
4. **Intel82801 IO Controller HUB.pdf**
5. **(Intel i7 interrupt registers and programming) 322165.pdf**

510111- Laboratory Practice- II

Teaching Scheme
Practical: 4 Hrs/week

Examination Scheme
OR: 50 Marks
TW: 50 Marks
Total Credits : 04

Use suitable 64-bit Linux environment and toolset to implement following assignments

1. Demonstrate the Reader-Writer Problem solution by creating multiple processes and share regions or blocks. Use 64-bit Linux derivative and tools for implementation.
2. Write a program to identify the least used icons/files/folders on the desktop and move them to temp folder created in Documents.
3. Create a computing facility grid using networks for Booth's multiplication (64-bit) using sign-extension method. Where bit multiplication, additions and merging of the addition results for final processing. The computing grid is created using Advanced wireless network with few computing resources are separated by the router and identified by the NAT. The network controlling node will be submitted with files having total distributed storage of 1000 numbers as a SAN queued for the execution in sorted manner on the lesser cost due to length of the multiplier and display the results along with the network tracking report for the dynamic allocation of multiplier and addition nodes along with the sleeping/ inactive/ unutilized nodes in the network.
4. Design suitable software architecture for assignment number 1,2 and 3 above.

Or assignments equivalent to the above assignments

5. Design and implement class/classes using latest 64-bit C++/JAVA/ Python/QT 5.1 and above, Cuda C++ or such latest 64-bit programming tools for the implementation of Two journal (IEEE Transactions/ACM Elsevier/Springer) papers published in the current year related to the respective elective subjects. Development Tools such as MATLAB/OPENCV/OPENMP/NS3 or equivalent may be used if required to interface the developed classes to the simulators.

Tools for the Laboratories: The laboratories must be equipped with adequate, well maintained working resources as per the software/equipment/tools list published by the Board of Studies time to time. For maintaining the quality and effective performance the Board of Studies may publish the quality guidelines for effective conduct of the laboratories, seminars and dissertation.

510112- Seminar- I

Teaching Scheme	**Examination Scheme**
Practical: 4 Hrs/week	**TW: 50 Marks**
	Presentation Oral: 50 Marks
	Total Credits: 04

State-of-the-art topic approved by the guide useful for professional growth in the filed of expertise. The presentation should cover motivation, mathematical modeling, data-table discussion and conclusion. The reports to be prepared using LATEX derivative. To maintain the quality of the seminar work it is mandatory on the seminar guides to maintain a progressive record of the seminar contact Hrs of 1 Hrs per month per seminar which shall include the discussion agenda, weekly outcomes achieved during practical sessions, corrective actions and comments on the progress report as per the plan submitted by the students including dates and timing, along with the signature of the student as per the class and teacher time table (as additional teaching load); such record of progressive work shall be referred by the examiners during evaluation.

Semester III

610101- Advanced Storage Systems and Infrastructure Management

Teaching Scheme
Lectures: 4 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 04

Objectives:

- Understanding components of modern information storage infrastructure.

Upon successful completion of this course, participants should be able to:

- Evaluate storage architecture; understand logical and physical components of a storage infrastructure including storage subsystems;
- Describe storage networking technologies and data archival solution;
- Understand and articulate business continuity solutions including, backup and recovery technologies, and local and remote replication solutions;
- Identify parameters of infrastructure management and describe common infrastructure management activities and solutions;

Prerequisites

To understand the content and successfully complete this course, a participant must have a basic understanding of computer architecture, operating systems, networking, and databases.

Unit I: Introduction to Information Storage Technology / Systems

Review data creation and the amount of data being created and understand the value of data to a business, Challenges in Data Storage and Management, Data Storage Infrastructure.
Components of a Storage System Environment: Disk drive components, Disk Drive performance, Logical Components.

Data protection: concept of RAID and different RAID levels (RAID 0, 1, 3, 5, 0+1/1+0, and 6);

Intelligent Storage System (ISS) and its components, Implementation of ISS as high-end and midrange storage arrays.

Unit II: Different Storage Technologies and Virtualization

Introduction to Networked Storage: Evolution of networked storage, Architecture, Overview of FC-SAN, NAS, and IP-SAN. Network-Attached Storage (NAS): Benefits of NAS, Components, Implementations, File Sharing, I/O operations, Performance and Availability.
Content Addressed Storage (CAS): features and Benefits of a CAS. CAS Architecture, Storage and Retrieval, Examples.

Storage Virtualization: Forms, Taxonomy, Configuration, Challenges, Types of Storage Virtualizations.

Overview of emerging technologies such as Cloud storage, Virtual provisioning, Unified Storage, FCOE, FAST.

Unit III: Business Continuity

Concept of information availability and its measurement, causes and consequences of downtime, concept of RTO, and RPO, single points of failure in a storage infrastructure and solutions for its mitigation, backup/recovery purposes and considerations, architecture and different backup/recovery topologies;

Local replication technologies and their operation, remote replication technologies and their operation, emerging technologies like de duplication, offsite backup.

Unit IV: Infrastructure Management Overview

Definitions, Infrastructure management activities, Evolutions of Systems since 1960s (Mainframes-to-Midrange-to-PCs-to-Client-server computing-to-New age systems) and their management, growth of internet, current business demands and IT systems issues, complexity of today's computing environment, Total cost of complexity issues, Value of Systems management for business.

Unit V: Preparing for Infrastructure Management

Factors to consider in designing IT organizations and IT infrastructure, Determining customer's Requirements, Identifying System Components to manage, Exist Processes, Data, applications, Tools and their integration, Patterns for IT systems management, Introduction to the design process for information systems, Models, Information Technology Infrastructure Library (ITIL).

Unit VI: Service Management

Service Delivery Processes- Service-level management, financial management and costing, IT services continuity management, Capacity management, Availability management.
Service Support Processes- Configuration Management, Service desk. Incident management. Problem management, Change management, Release management.

Reference Books:

1. EMC Educational Services, Information Storage and Management, Wiley India,.
2. Robert Spalding, “Storage Networks: The Complete Reference“, Tata McGraw Hill, Osborne, 2003.
3. Marc Farley, “Building Storage Networks”, Tata McGraw Hill ,Osborne, 2001.
4. Jan Van Bon, “Foundations of IT Service Management: based on ITIL”, Van Haren Publishing, 2nd edition 2005
5. Harris Kem, Stuart Gaiup, Guy Nemiro, “IT Organization: Building a Worldclass Infrastructure”, Prentice Hall, 2000
6. Richard Barker and Paul Massiglia, .Storage Area Network Essentials: A Complete Guide to Understanding and Implementing SANs., Wiley India.
7. Meet Gupta, Storage Area Network Fundamentals., Pearson Education Limited, 2002.

610102- Advanced Unix Programming

Teaching Scheme **Examination Scheme**

Lectures: 4 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 04

Unit I. Introduction to UNIX File system

Introduction to UNIX file system, file handling utilities, securities and file permissions, process utilities, Disk utilities, networking commands, Introduction to shell scripting, Working with Bourn shell: Shell responsibilities, PIPES and input and output redirection, Shell variables, Shell commands, Control structures, Shell script examples, ext4, IA-64 Architecture: Userlevel Instruction Set Architecture, Runtime and Software Conventions, System Instruction Set Architecture, The Register Stack Engine (RSE). Kernel Entry and Exit: Interuptions, System Calls, Signals, Kernel acces to user memory, Stack unwinding: IA-64 ELF unwind sections The Kernel Unwind Interface, Embedding unwind information in Assembly code, Implementation Aspects.

Unit II. Process Management

Process management and working of signals in Unix - process definition, its relation with its environment through environment variables, command-line arguments; process memeory layout; process creation-fork(), process control - wait(), waitpid(); program loading-exec() family; process termination-exit(), _exit(); non-local goto-setjmp(), longjmp(); signals-signal disposition, reliable and unreliable ways of signals, creation, pending and delivery stages;signal sets-blocking, unblocking; useful signals-SIGINT, SIGKILL, SIGTERM, SIGALRM, alarm(), pause(), ELF64, Linux Tasks, Virtual Memory Management, Address space for Linux Process, Page Tables, Translation Lookahead Buffers, Page Faults, Memory Coherancy, Switching Address spaces.

Unit III. Advanced I/O in Unix

Introduction, Streams and file objects, Standard Input, Standard Output, and Standard Error, Buffering, opening reading & writing in streams, Nonblocking I/O, Record locking, streams, I/O multiplexing, asynchronous I/O, readv & writev functions, readn & writen functions, Memory mapped I/O,

Unit IV. Inter-process Communication

Inter Processes communication within the system and their applications in network programming: types of IPC-pipes, FIFOs, Message Queues, Semaphores, Shared memory; pipes-characteristics, creating a pipe, writing and reading from a pipe, popen(), synchronization, process pipe-lining, co-processes; FIFO-names pipe, characteristics, contrast with pipes, opening, reading and writing, non-blocking option; Message Queues-characteristics, contrast with pipes/fifos, concept of key space, identifier, fork(), msgget(), msgsnd(), msgrcv(),msgctl(); semaphores- characteristics, semget(),semop(),semctl(), semadj variable usage; shared memory-characteristics, fastest IPC, shmget(),shmat(),shmdt(0,shmctl().

Unit V. Multithreading in UNIX

Different models of concurrent server design: Multiplexing, Forking, Multithreading, Preforking, Prethreading, Preforking and Prethreading; Preforking Models; Prethreading Models. To understand remote procedure calls and practice: RPC model; stubs and skeletons; call semantics. Thread Interface, Thread Synchronization, Symetric Multiprocessing: Multiprocesing on Linux, Linux Locking Principles, Multiprocessor support Interface, CPU-specific Data area.

Unit VI. Introduction to Socket

Understanding of sockets: what is a socket, Study of different types of sockets: Raw sockets, Unix Domain sockets, TCP & UDP sockets, Routing sockets, socket pair, socket descriptor, socket address structure for IPv4 , end point addressing, Study of simple, protocol dependent socket program: Design of a simple client and server: daytime server , echo server with and without threading .

References:

1. Advanced Programming in the UNIX-W. Richard Stevens
2. Unix Network Programming: Vol-II Inter Process Communications
3. IA-64 Linux Kernel: Design and Implementation, David Mosberger, Hewlett-Packard Professional Books, ISBN13: 9780130610140, ISBN10: 0130610143

Additional References:

1. The Design of the Unix Operating System- Maurice J. Bach

Elective III

610103A - Network Security

Teaching Scheme	Examination Scheme
Lectures: 5 Hrs/week	**Theory In-semester Assessment: 50 Marks**
	Theory End-semester Assessment: 50 Marks
	Total Credits : 05

Unit I. Introduction

Security Trends, the OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms, A model for Network Security The Security problems, Avenues of Attacks

Unit II. Security at each layer :

Security at Application Layer : PGP, and S/MIME, Email Security Security at Transport Layer : SSL & TLS, SSL Architecture, Four Protocols, SSL message formats, Transport layer security Security at Network Layer : IPSec, Two Modes, Two Security Protocols, Security Association, security Policy, Internet Key Exchange (IKE), ISAKMP

Unit III. System Security :

Description of the system, Users, Trust and Trusted systems, Buffer overflow and Malicious software, malicious program, worm, viruses, IDS, Firewall.

Firewalls: Network Partitioning, firewall platforms, partitioning models and methods, Secure SNMP, Secure routing interoperability, virtual network.

Unit IV. Cryptographic Techniques

Secret versus " Public" key Cryptography, Types of attack, Types of cipher - Substitution, transposition, Other Cipher properties, Secret key cryptography , Public key cryptography and RSA key management, digital certificates, PKI, identity based encryption, Authentication

Unit V. Security Policies and Design Guidelines

Policies: Policy creation, Regularity considerations, Privacy regulations. Security: Infrastructure and components. Design Guidelines. Authentication: Authorization and accounting. Physical and logical access control. User authentication: Biometric devices.

Unit VI. Web Security

Computer Forensics: evidence , collecting Evidence Chain of Custody, free space vs Stack space. TCP/IP Vulnerabilities : Securing TCP/IP Spoofing: The process of an IP spoofing attack, Cost of Spoofing, Types of spoofing, spoofing tools, prevention and Mitigation

References:

1. Cryptography and Network Security – Principles and Practices – William Stallings
2. Cryptography and Network Security – Forozan an Mukhopadhay – Mc Graw Hill
3. Information Assurance & security Series Principles of Computer Security, Security + and Beyond – Conklin, White, Cothren, Williams, Davis – Dreamtech Press
4. Cheswick W. Bellovin S. " Firewall and Internet security Repelling the Wily Hacker", 2nd Addison Wesley
5. Security Architecture, design, deployment and operations – Christophr M King , Curtis, Dalton and T Ertem Osmanoglu
6. Computer Security Concepts, Issues and Implementation – Alfred Basta, Wolf Halton – Cengage Learning

610103B - Cloud Computing

Teaching Scheme	Examination Scheme
Lectures: 5 Hrs/week	**Theory In-semester Assessment: 50 Marks**
	Theory End-semester Assessment: 50 Marks
	Total Credits : 05

Unit I. Introduction

Cloud computing fundamentals, the role of networks in Cloud computing, Essential characteristics of Cloud computing, Cloud deployment model, Cloud service models, Multitenancy, Cloud cube model, Cloud economics and benefits, Cloud types and service scalability over the cloud, challenges in cloud NIST guidelines

Unit II. Virtualization, Server, Storage and Networking

Virtualization concepts , types, Server virtualization, Storage virtualization, Storage services, Network virtualization, Service virtualization, Virtualization management, Virtualization technologies and architectures, Internals of virtual machine, Measurement and profiling of virtualized applications. Hypervisors: KVM, Xen, HyperV Different hypervisors and features

Unit III. Data in cloud

Storage system architecture, Big data, Virtualized Data Centre (VDC) architecture, VDC environments, concepts, planning and design, Managing VDC and cloud infrastructures,
hybrid storage networking technologies (iSCSI, FCIP,FCoE), host system design consideration

Unit IV. Cloud security

Cloud Security risks, Security, Privacy, Trust, Operating system security, Security of virtualization, Security risks posed by shared images, Security risk posed by a management OS, Xoar, Trusted virtual machine monitor

Unit V. QoS [Quality of Service] of Cloud

Taxonomy and survey of QoS management and service , Selection methodologies for cloud computing, Auto scaling, Load balancing and monitoring in open source cloud, Resource scheduling for Cloud Computing

Unit VI. Cloud patterns and application

Cloud Platforms: Amazon EC2 and S3, Cloudstack, Intercloud, Mobile Cloud Designing an image: Pre-packaged image, singleton instances prototype images Designing an architecture : Adapters, Facades, Proxies and balancers Clustering : The n-Tier Web pattern, Semaphores and Locking Map Reduce Peer-to-Peer framework

References:

1. Dr. Kumar Saurabh,"Cloud Computing", Wiley Publication
2. Borko Furht, "Handbook of Cloud Computing", Springer
3. Venkata Josyula,"Cloud computing – Automated virtualized data center", CISCO Press
4. Greg Schulr,"Cloud and virtual data storage networking",CRC Press
5. Mark Carlson,"Cloud data management and storage", Mc Graw hill
6. Lizhe Wang, " Cloud Computing:Methodology, System and Applications", CRC Press
7. Cloud computing: Data Intensive Computing and Scheduling by Chapman Hall/CRC
8. Christopher M. Moyer, Building Applications in the Cloud: Concepts, Patterns, and Projects

9. Dan C. Marinescu,” Cloud computing: Theory and Practice”,

Additional References:

1. Antonopoulus, Nikos, ”Cloud computing: Principles, Systems and Applications”,1st edition
2. Ronald Krutz,”Cloud Security: Comprehensive guide to Secure Cloud Computing”, Wiley Publishing
3. Barrie Sosinsky,”Cloud Computing Bible”, Wiley
4. Rajkumar Buyya,”CLOUD COMPUTING Principles and Paradigms”,Wiley and Sons, Inc
5. Anthony T. Velte, “Cloud Computing: Practical Approach”, Mc Graw Hill
6. Tim Mather,”Cloud Security and Privacy”, O’REILLY
7. Gautham Shroff, “Enterprise Cloud Computing”, Cambridge

610103C - Computer Vision and Pattern Recognition

Teaching Scheme
Lectures: 5 Hrs/week

Examination Scheme
Theory In-semester Assessment: 50 Marks
Theory End-semester Assessment: 50 Marks
Total Credits : 05

Unit I. Basics of Digital Imaging

Image Acquisition, Sampling, Quantization, Difference in Monochrome and Multichrome imaging, concept of color spaces, point processing techniques, mask processing methods, image filtering, shape in images, edge detection, gradient operators- Roberts, Sobel, Prewitt, Canny, Slope magnitude method, morphological image processing, erosion, dilation, opening, closing, hit-n-miss transform, thinning, Top Hat transformation, Bottom hat transformation.

Unit II. Image Representation and Region Analysis

Shape Descriptors-contour based, region based, Boundary based; Thresholding based segmentation, Watershed based Segmentation, Gray level Co-occurrence Matrix-energy, entropy, maximum probability, contrast, correlation; wavelets, wavelet Pyramids, Image matching, similarity measures, feature extraction in spatial domain, block truncation coding, feature extraction in transform domain, image transforms, energy based feature extraction.

Unit III. Computer Vision Applications

Image Fusion and Clustering- K-means, Vector Quantization, Hierarchical Clustering, Partitioned Clustering, Image Inpainting, Multisensor image fusion, character recognition, face recognition, Trademark databases, Medical Imaging, Signature Verification, Vehicular license plate Recognition, image and Video retrieval, Surveillance, Robotic vision, Panoramic view Construction

Unit IV. Introduction to Pattern Recognition

Tree Classifiers-Decision Trees, Random Forests; Bayesian Decision Theory; Linear Discriminants Discriminative Classifiers- Separability, Perceptions, Support Vector Machines.

Unit V. Decision Theory

Parametric Techniques Generative Methods grounded in Bayesian Decision Theory: Maximum Likelihood Estimation, Bayesian Parameter Estimation, Sufficient Statistics; Non-Parametric Techniques- Kernel Density Estimators, Parzen Window, Nearest Neighbor Methods; Unsupervised Methods Exploring the Data for Latent Structure- Component Analysis and Dimension Reduction, principal Component Analysis

Unit VI. Clustering

K-Means, Expectation Maximization, Mean Shift, Vector Quantization- Codebook generation Methods; Classifier Ensembles- Bagging, Boosting / AdaBoost; Graphical Models The Modern Language of Pattern Recognition and Machine Learning- Bayesian Networks, Sequential Models; Neural Networks

Reference Books

1. Robert Haralick and Linda Shapiro, "Computer and Robot Vision", Vol I, II, Addison Wesley, 1993.
2. David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach" PHI
3. R Jain, R Kasturi, , "Machine Vision", McGraw Hill
4. R. O. Duda, P. E. Hart, D. G. Stork, “Pattern Classification”, 2nd Edition, Wiley-Inter-science, John Wiley &Sons, 2001
5. David G. Stork and Elad Yom-Tov, “Computer Manual in MATLAB to accompany Pattern Classification” Wiley Inter-science, 2004

610103D- Soft Computing

Teaching Scheme **Examination Scheme**

Lectures: 5 Hrs/week **Theory In-semester Assessment: 50 Marks**

Theory End-semester Assessment: 50 Marks

Total Credits : 05

Objectives:

- Design and develop intelligent systems in the framework of soft computing, and to acquire knowledge of scientific application-driven environments.

Outcomes:

Students who successfully complete this course will be able to

- Have a general understanding of soft computing methodologies, including artificial neural networks, fuzzy sets, fuzzy logic, fuzzy inference systems and genetic algorithms;
- Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications.

Unit I: Soft Computing Basics

Introduction, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing. Basic tools of soft computing – Fuzzy logic, neural network, evolutionary computing. Introduction: Neural networks, application scope of neural networks, fuzzy
logic, genetic algorithm, hybrid systems.

Unit II: Neural Networks

Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory, perceptron model, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications.

Unit III: Fuzzy Logic

Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion. Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzifications, Fuzzy Controller, Fuzzy rule base and approximate reasoning: truth values and tables in fuzzy logic, fuzzy propositions formation of rules ,decomposition of compound rules, aggregation of fuzzy rules, fuzzy reasoning, fuzzy inference system, fuzzy expert systems.

Unit IV: Genetic Algorithm

Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, Traditional algorithm vs genetic algorithm, simple GA, general genetic algorithm, schema theorem, Classification of genetic algorithm, Holland classifier systems, genetic programming, applications of genetic algorithm, Convergence of GA, Applications & advances in GA, Differences & similarities between GA & other traditional method, applications.

Unit V: Evolutionary computing

Role of biologically inspired software, Difficulties in search, optimization and machine learning, Overview of natural evolution and its abilities, Evolutionary Programming/Evolutionary Strategies
Issues in evolutionary search, applying an evolutionary algorithm, Artificial Life, Ant colony optimization, Swarm intelligence

Unit VI: Application areas of soft computing

Optimization, function regression, Scheduling, Fraud detection, Anomaly detection, Design Robot or agent control, Interactive tools such as music composition, art generation, decision making and others.

Text Books:

1. S. Rajsekaran & G.A. Vijayalakshmi Pai, “Neural Networks,Fuzzy Logic and Genetic Algorithm:Synthesis and Applications” Prentice Hall of India.
2. N.P.Padhy,”Artificial Intelligence and Intelligent Systems” Oxford University Press.
3. Neuro-Fuzzy and Soft Computing, J S R Jang, CT Sun and E.Mizutani , PHI PVT LTD.
4. Principles of soft computing –by Sivandudam and Deepa, John Mikey India.

Reference Books:

1. Siman Haykin,”Neural Netowrks”Prentice Hall of India
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India.
3. Eiben and Smith, “Introduction to Evolutionary Computation", Springer.

610104 - Seminar- II

Teaching Scheme
Practical: 4 Hrs/week

Examination Scheme
TW: 50 Marks
Presentation Oral: 50 Marks
Total Credits: 04

Seminar based on state-of-the art in the selected electives. The presentation and the report should cover motivation, mathematical modeling, data-table discussion and conclusion. The reports to be prepared using LATEX derivative. To maintain the quality of the seminar work it is mandatory on the seminar guides to maintain a progressive record of the seminar contact Hrs of 1 Hrs per month per seminar which shall include the discussion agenda, weekly outcomes achieved during practical sessions, corrective actions and comments on the progress report as per the plan submitted by the students including dates and timing, along with the signature of the student as per the class and teacher time table (as additional teaching load); such record of progressive work shall be referred by the examiners during evaluation.

610105 – Dissertation Stage-I

Teaching Scheme
Practical: 8 Hrs/week/student

Examination Scheme
TW: 50 Marks
OR: 50 Marks
Total Credits: 08

Motivation, Problem statement, survey of journal papers related to the problem statement, problem modeling and design using set theory, NP-Hard analysis, SRS, UML, Classes, Signals, Test scenarios and other necessary, problem specific UML, software engineering documents. Student should publish one International Journal Paper (having ISSN Number and preferably with Citation Index II); or paper can be published in reputed International Journal recommended by the guide of the Dissertation and in addition to above the term work shall include the paper published, reviewers comments and certificate of presenting the paper in the conference organized/sponsored by the Board of Studies in Computer Engineering. To maintain the quality of the dissertation work it is mandatory on the dissertation guides to maintain a progressive record of the dissertation contact Hrs of 1 Hrs per week which shall include the dissertation discussion agenda, weekly outcomes achieved during practical sessions, corrective actions and comments on the progress report as per the plan submitted by the students including dates and timing, along with the signature of the student as per the class and teacher time table; such record of progressive work shall be referred by the dissertation examiners during evaluation. At the most 8 dissertations can be assigned to a guide.

Important Note regarding all Open Electives

Open Elective proposal shall be (current state-of the art in Computer Engineering or Inter-disciplinary or intra-disciplinary) focusing algorithms, technologies developed using computing or systems programming (Kernel level/ Embedded) or virtualization or useful for the professional growth, if any, to be forwarded to the BoS, Computer Engineering for necessary approvals on or before the month of December every year. The teaching shall be done through Industry-Institute Interaction/invited talks/webminars etc.

Semester - IV

610106 - Seminar- III

Teaching Scheme
Practical: 5 Hrs/week

Examination Scheme
TW: 50 Marks
Presentation Oral: 50 Marks
Total Credits: 05

Seminar based on selected research methodology preferably algorithmic design advances as an extension to seminar-II. The presentation should cover motivation, mathematical modeling, data-table discussion and conclusion. The reports shall be prepared using LATEX derivative. To maintain the quality of the seminar work it is mandatory on the seminar guides to maintain a progressive record of the seminar contact Hrs of 1 Hrs per month per seminar which shall include the discussion agenda, weekly outcomes achieved during practical sessions, corrective actions and comments on the progress report as per the plan submitted by the students including dates and timing, along with the signature of the student as per the class and teacher time table (as additional teaching load); such record of progressive work shall be referred by the examiners during evaluation.

610106 – Dissertation Stage-II

Teaching Scheme
Practical: 20 Hrs/week/student

Examination Scheme
TW: 150 Marks
OR: 50
Total Credits: 20

Selection of Technology, Installations, UML implementations, testing, Results, performance discussions using data tables per parameter considered for the improvement with existing known algorithms and comparative graphs to support the conclusions drawn. Student should publish one International Journal Paper (having ISSN Number and preferably with Citation Index II); or paper can be published in reputed International Journal recommended by the guide of the Dissertation and in addition to above the term work shall include the paper published, reviewers comments and certificate of presenting the paper in the conference organized/sponsored by the Board of Studies in Computer Engineering. To maintain the quality of the dissertation work it is mandatory on the dissertation guides to maintain a progressive record of the dissertation contact Hrs of 1 Hrs per week which shall include the dissertation discussion agenda, weekly outcomes achieved during practical sessions, corrective actions and comments on the progress report as per the plan submitted by the students including dates and timing, along with the signature of the student as per the class and teacher time table; such record of progressive work shall be referred by the dissertation examiners during evaluation. At the most 8 dissertations can be assigned to a guide.

Important Note Regarding all Open Electives

Open Elective proposal shall be (current state-of the art in Computer Engineering or Inter-disciplinary or intra-disciplinary) focusing algorithms, technologies developed using computing or systems programming (Kernel level/ Embedded) or virtualization or useful for the professional growth, if any, to be forwarded to the BoS, Computer Engineering for necessary approvals on or before the month of December every year. The teaching shall be done through Industry-Institute Interaction/invited talks/webminars etc.

Tools for the Laboratories: The laboratories must be equipped with adequate, well maintained working resources as per the software/equipment/tools list published by the Board of Studies time to time. For maintaining the quality and effective performance the Board of Studies may publish the quality guidelines for effective conduct of the laboratories, seminars and dissertation.