COEP Technological University, Pune

School of Computation Sciences

Department of Computer Science and Engineering

M. Tech in Computer Engineering

Curriculum Structure and Detailed Syllabus

w.e.f AY 2024-25

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Program Educational Objectives (PEOs)

PEO 1. To make students eligible to take up higher studies/research
PEO 2. To build competency among students to take up jobs that require technical expertise and problem solving ability
PEO 3. To inculcate readiness among students for self learning
PEO 4. To build competency among students in applying technology to solve real-life socio-economic problems

Program Outcomes (POs)

The post-graduate students will demonstrate:

PO 1. An ability to independently carry out research /investigation and development work to solve practical problems
PO 2. An ability to write and present a substantial technical report/document
PO 3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO 4. Ability to manage/work in teams with diverse backgrounds in different aspects (such as language, region, technical proficiency, engineering discipline etc) and communicate effectively
PO 5. Ability to life-long self learning and to keep oneself up-to-date in the field of technology
PO 6. Understand intellectual property rights and the ability to apply them in an appropriate manner

Correlation between the PEOs and the POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
PEO 1	√	√	√		√	√
PEO 2	√		√	√	√	
PEO 3			√		√	
PEO 4	√	√	√		√	

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.88%
PSBC	Program Specific Bridge Course	1	3	4.41%
PCC + LC	Program Core Course + Laboratory Course	5	20	29.41%
PCC	Program Core Course	1	3	4.41%
DEC	Department Elective Course	3	9	13.24%
CCA	C-curricular and Extra Curricular Activities	1	1	1.47%
OE	Open Elective	1	3	4.41%
SLC	Self Learning Course	2	6	8.82%
VSEC	Vocational and Skill Enhancement Course	2	18	26.47%
MLC	Mandatory Learning Course	2	0	0
AEC	Ability Enhancement Course	1	1	1.47%
	Total	25	68	100%

Curriculum Structure

Semester I

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	PSMC	<tbd>	Probability, Statistics and Queuing Theory	3	1	0	1	4	30	10	60	-	-
2.	PSBC	<tbd>	Algorithms and Complexity Theory	3	0	0	1	3	30	10	60	-	-
3.	PCC & LC	<tbd>	Topics in Databases	3	0	2	1	4	30	10	60	50	50
4.	PCC & LC	<tbd>	Advanced Computer Networks	3	0	2	1	4	30	10	60	50	50
5.	PCC	<tbd>	Advanced Computer Architecture	3	0	0	1	3	30	10	60	-	-
6.	DEC	<tbd>	Department Elective -I 1) Distributed Operating Systems 2) Artificial Intelligence 3) Advanced Graph Theory 4) Courses in association with Industry	3	0	0	1	3	30	10	60	-	-
7.	MLC	<tbd>	Research Methodology and Intellectual Property Rights	0	0	0	2	0	30	10	60	-	-
8.	MLC	<tbd>	Effective Technical Communication	0	0	0	1	0	30	10	60	-	-
9.	AEC	<tbd>	Mini Project/ Seminar	0	0	2	1	1	-	-	-	50	50
Total Credits								22					

Legends:

L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits,

ISE: In-Semester-Evaluation, ESE: End-Semester-Evaluation, MSE: Mid-Semester Evaluation, TA: Teacher's Assessment, CIE: Continuous-Internal-Evaluation

Semester II

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1.	OE	<tbd>	Open Elective	3	0	0	1	3	30	10	60	-	-
2.	PCC & LC	<tbd>	Data Mining and Machine Learning	3	0	2	1	4	30	10	60	50	50
3.	PCC & LC	<tbd>	Security in Computing	3	0	2	1	4	30	10	60	50	50
4.	PCC & LC	<tbd>	Embedded Systems	3	0	2	1	4	30	10	60	50	50
5.	PEC	<tbd>	Department Elective -II 1) Cloud Computing and Virtualization 2) Natural Language Processing 3) Parallel Algorithms 4) Courses in association with Industry	3	0	0	1	3	30	10	60	-	-
6.	PEC	<tbd>	Department Elective -III 1) Advanced Compiler Construction 2) Deep Learning 3) Multicore Technology 4) Courses in association with Industry	3	0	0	1	3	30	10	60	-	-
7.	CCA	<tbd>	Liberal Learning Course	0	0	2	2	1	-	-	-	100	-
Total Credits								**22**					

- The department offers “Data Structures” as Open Elective for students of other departments.
- Exit option to qualify for PG Diploma in Computer Engineering:
    - Eight weeks domain-specific industrial internship in the month of June-July after successfully completing the first year of the program

Semester III

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	SLC	<tbd>	Massive Open Online Course –I	3	0	0	1	3	-	-	100	-	-
2	SLC	<tbd>	Massive Open Online Course –II	3	0	0	1	3	-	-	100	-	-
3	VSEC	<tbd>	Dissertation Phase – I	0	0	12	18	6	-	-	-	40	60
			Total Credits					12					

Semester IV

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	VSEC	<tbd>	Dissertation Phase – II	0	0	24	12	12	-	-	-	40	60
			Total Credits					12					

Detailed Syllabus – Semester I

[PSMC] Probability, Statistics and Queuing Theory

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 10 marks
Tutorial: 1 hour/week	ESE: 60 marks
Self-Study: 1 hour/week	

Course Outcomes

Students will be able to:

1. Solve problems related to basic probability theory
2. Solve problems related to basic concepts and commonly used techniques of statistics
3. Model a given scenario using continuous and discrete distributions appropriately and estimate the required probability of a set of events
4. Apply the theory of probability and statistics to solve problems in domains such as machine learning, data mining, computer networks etc.

Unit 1: Basic Probability Theory [2 hrs]

Probability axioms, conditional probability, independence of events, Bayes' rule, Bernoulli trials

Unit 2: Random Variables and Expectation [10 hrs]

- Discrete random variables: Random variables and their event spaces, Probability Mass Function, Discrete Distributions such as Binomial, Poisson, Geometric etc., Indicator random variables
- Continuous random variables: Distributions such as Exponential, Erlang, Gamma, Normal etc., Functions of a random variable
- Expectation: Moments, Expectation based on multiple random variables, Transform methods, Moments and Transforms of some distributions such as Binomial, Geometric, Poisson, Gamma, Normal

Unit 3: Stochastic Processes [6 hrs]

Introduction and classification of stochastic processes, Bernoulli process, Poisson process, Renewal processes

Unit 4: Markov chains [8 hrs]

- Discrete-Time Markov chains: computation of n-step transition probabilities, state classification and limiting probabilities, distribution of time between time changes, M/G/1 queuing system
- Continuous-Time Markov chains: Birth-Death process (M/M/1 and M/M/m queues), Non-birth-death processes, Petri nets

Unit 5: Statistical Inference [8 hrs]

Parameter Estimation – sampling from normal distribution, exponential distribution, estimation related to Markov chains, and Hypothesis testing.

Unit 6: Regression and Analysis of Variance [6 hrs]

Least square curve fitting, Linear and non-linear regression, Analysis of variance.

Text Book

1. Ronald Walpole, Probability and Statistics for Engineers and Scientists, Pearson, ISBN-13: 978-0321629111

Reference Book

1. Kishor Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications, John Wiley and Sons, New York, 2001, ISBN number 0- 471-33341-7

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	3	-	-
CO 2	2	2	3	2	-	-
CO 3	2	1	2	3	-	-
CO 4	3	2	3	2	-	-

[PSBC] Algorithms and Complexity Theory

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Determine different time complexities of a given algorithm
2. Demonstrate various design techniques using typical algorithms
3. Develop algorithms using various design techniques for a given problem.
4. Formalize and abstract from a given computational task relevant computational problems, reduce problems and argue about complexity classes

Unit 1: Mathematical Foundation **[6 hrs]**

Growth of functions – Asymptotic notation, Standard notation and common functions, Summations, solving recurrences.

Unit 2: Analysis of Algorithms **[8 hrs]**

Necessity of time and space requirement analysis of algorithms, Worst-case analysis of common algorithms and operations on elementary data structures (e.g. Heapsort), Average case analysis of Quicksort, Amortized analysis.

Unit 3: Standard Design Techniques-I **[6 hrs]**

Divide and Conquer, Greedy method.

Unit 4: Standard Design Techniques-II **[8 hrs]**

Dynamic programming, Graphs and Traversals.

Unit 5: Standard Design Techniques-III **[6 hrs]**

Backtracking, Branch-and-bound.

Unit 6: Complexity Theory **[6 hrs]**
Lower-bound arguments, Introduction to NP-Completeness, Reducibility (SAT, 3VC, Independent Set, Subset Sum, Hamiltonian Circuit etc.), Introduction to approximation algorithms.

Text Book

1. Thomas Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", PHI, 2009

Reference Book

1. E. Horowitz and S. Sahni. "Fundamentals of Computer Algorithms", Galgotia, 1991

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	1	1	-
CO 2	2	1	3	1	1	-
CO 3	2	1	3	1	1	-
CO 4	2	1	3	1	1	-

[PCC&LC] Topics in Databases

Teaching Scheme
Lectures: 3 hours/week
Labs: 2 hours / Week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks
Laboratory: CIE: 50 marks,
ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Understand the foundation of RDBMS theory and the internal functionary of RDBMS.
2. Understand and analyze advanced topics of RDBMS and the latest trends of RDBMS
3. Relate theory with practice by performing programming assignments
4. Analyze various algorithms and implementation options to solve a problem
5. Demonstrate familiarity with how query optimizations are done in real-life database systems
6. Apply the Map Reduce technique for solving a few problems in a distributed manner

Unit 1: Transaction Management **[10 hrs]**

- Overview of transaction management: Transaction Concept, Transaction State, Implementation of Atomicity and Durability, Concurrent Executions, Serializability, Recoverability
- Concurrency Control: Lock-Based Protocols, Timestamp-Based Protocols, Validation-Based Protocols
- Recovery System: Recovery and Atomicity, Log-Based Recovery, Recovery with Concurrent Transactions, ARIES (Algorithm for Recovery and Isolation Exploiting Semantics), which supports partial rollbacks of transactions, fine granularity (e. g., record) locking and recovery using write-ahead logging (WAL)

Unit 2: Query Execution **[10 hrs]**
Architecture of Query Execution Engines, Disk Access, Measures of Query Cost, Introduction to Physical-Query-Plan Operators, One-Pass Algorithms for Database Operations, Nested-Loop Joins, Two-Pass Algorithms Based on Sorting, Two-Pass Algorithms Based on Hashing, Index-Based Algorithms, Algorithms Using More Than Two Passes.

Unit 3: Query Optimization **[10 hrs]**
Basic Optimization Strategies, Algebraic Manipulation, Optimizations of Selections in System R.

Unit 4: Case Studies **[10 hrs]**
Hadoop Distributed File System: Study of Hadoop Distributed File System, HIVE - Data warehousing application built on top of Hadoop, MapReduce framework, Dynamo – a structured storage system, Eventual Consistency Model for Distributed Systems.

Text Books and Research Papers

1. Hector Garcia-Molina, Jeffrey D. Ullman and Jennifer Widom, "Database System:The Complete Book", Pearson, 2nd edition (2008), ISBN-10: 0131873253, ISBN-13: 978-0131873254
2. Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", McGraw Hill Education, 3rd edition (2014), ISBN-10: 9339213114, ISBN-13: 978- 9339213114
3. C. Mohan, "ARIES: A Transaction Recovery Method Supporting Fine-Granularity Locking and Partial Rollbacks Using Write-Ahead Logging", ACM Transactions on Database Systems, Vol. 17, No. 1, March 1992, pp. 94–162.
4. P. Selinger, M. Astrahan, D. Chamberlin, Raymond Lorie and T. Price, "Access Path Selection in a Relational Database Management System", Proceedings of ACM SIGMOD, pp 23-34, 1979
5. Jeffrey Dean and Sanjay Ghemawat, "MapReduce: Simplified Data Processing on Large Clusters", Communications of the ACM, vol. 51, no. 1, pp. 107-113, 2008
6. Fay Chang, Jeffrey Dean, Sanjay Ghemawat, Wilson C. Hsieh, Deborah A. Wallach, Mike Burrows, Tushar Chandra, Andrew Fikes, and Robert E. Gruber, "Bigtable: A Distributed Storage System for Structured Data", Proceedings of Operating Systems Design and Implementation, pp. 205-218, 2006.
7. W. Vogels, "Eventually Consistent", ACM Queue, vol. 6, no. 6, December 2008
8. Goetz Graefe, "Query Evaluation Techniques for Large Databases", ACM Computing Surveys, Vol. 25, No. 2, June 1993

Reference Books

1. Korth, Silberschatz and Sudarshan, "Database System Concepts", Tata McGraw Hill, 6th edition (2013), ISBN-10: 9332901384, ISBN-13: 978-9332901384
2. R. Elmasri, and S. Navathe, "Fundamentals of Database Systems", Pearson, 7th edition (2017), ISBN-10: 9789332582705, ISBN-13: 978-9332582705

Internet Resource

1. http://hadoop.apache.org

Suggested List of Assignments in the Laboratory:

1. Write a program to check if a given schedule is serial, serializable, conflictserilaizable.

2. Simulate recovery using undo, redo and undo-redo logging.
3. Simulate ARIES recovery system.
4. Implement disk-based algorithms for sorting.
5. Implement hash-based natural join, sort-based natural-join.
6. Study MySQL/Postgres query optimizer code.
7. Comparing the query evaluation performance before and after applying query optimization techniques.
8. Implementation of MapReduce algorithms for Matrix multiplication and GroupBy operation

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	2	2	-
CO 2	3	1	3	2	3	-
CO 3	3	2	3	2	3	-
CO 4	3	1	3	2	3	-
CO 5	3	1	3	2	2	-
CO 6	3	1	3	3	3	-

[PCC&LC] Advanced Computer Networks

Teaching Scheme
Lectures: 3 hours/week
Labs: 2 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks
Laboratory: CIE: 50 marks,
ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Gain a deep understanding of advanced concepts in next-generation computer networks.
2. Analyze TCP/IP network algorithms, protocols, tools, and functionalities.
3. Grasp the features of Software-Defined Networking (SDN) and its applications in next-generation systems.
4. Understand and compare different storage and networking technologies.
5. Implement various network algorithms and applications to solve specific network problems.
6. Explore tools and simulate scenarios for wired and wireless networks, followed by performance analysis.

Unit 1 **[6 hrs]**

IPv4 deficiencies, patching work done with IPv4, IPv6 addressing, multicast, Anycast, ICMPv6, Intra and Interdomain Routing Algorithms, Neighbour discovery, IGMP

Unit 2 **[6 hrs]**

Transport Layer protocols, Congestion Control, Quality of Service, Queue Management, Differentiated Service, Traffic Policing, Traffic Shaping

Unit 3 **[6 hrs]**

Centralized and Distributed Control and Data Planes, SDN Controllers, Deep Dive (Northbound and

Southbound interface), Network Function Virtualization, Mininet, Programming in SDNs with Openflow, Openstack Neutron plug-in

Unit 4 **[6 hrs]**
MAC Protocols for Ad Hoc Wireless Networks, Routing Protocols for Ad Hoc Wireless Networks, Multicast routing in Ad Hoc Wireless Networks, Transport Layer and Security Protocols for Ad Hoc Wireless Networks, Quality of Service in Ad Hoc Wireless Networks.

Unit 5 **[6 hrs]**
Network Management: Organization and Information Models, SNMPv1, SNMPv2 Major changes, Management Information Base, SNMPv3, RMON, Network Management Tools.

Unit 6 **[6 hrs]**
Storage and Networking Concepts, Fiber Channel Internals, Fiber Channel SAN Topologies, Fiber Channel Products, IP SAN Technology, IP SAN Products, Management of SANs, SAN Issues.

Self Study:
TCP/IP network stack, Data Link Layer, Application Layer, Wireshark took, NS-2 Simulator

Text Books

1. William Stallings, High-Speed Networks and Internets, Pearson Education, 2nd Edition, 2002.
2. C. Siva Ram Murthy, B.S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall, 2004
3. Thomas D Nadeau and Ken Grey, Software Defined Networking, O'Reilly, 2013.
4. Mani Subramanian, Timothy A. Gonsalves, N. Usha Rani; Network Management: Principles and Practice; Pearson Education India, 2010

Reference Books

1. Muthukumaran B, Introduction to High Performance Networks, Tata Mc Graw Hill, 2008
2. Goransson P, Black C, Culver T. Software Defined Networks: a Comprehensive Approach. Morgan Kaufmann; 2014.
3. Chayapathi R, Hassan SF, Shah P. Network Functions Virtualization (NFV) with a Touch of SDN, Addison-Wesley Professional; 2016 Nov 14.
4. Pete Loshin, IPv6: Theory, Protocols and Practice, Morgan Kaufmann, 2nd Edition, 2004
5. Marschke D, Doyle J, Moyer P. Software Defined Networking (SDN): Anatomy of OpenFlow Volume 1, 2015.
6. Tom Clark, Designing Storage Area Networks, A Practical Reference for Implementing Fibre Channel and IP SANs, Addison-Wesley Professional, 2nd Edition, 2003.
7. Stevens, `UNIX Network Programming, Vol. 1: Networking APIs: Sockets and XTI,' 2nd ed., Prentice-Hall, 1997
8. Morris, Network Management, 1st Edition, Pearson Education, 2008.

Suggested List of Assignments in the Laboratory:

1. Implement client-server communication employing socket API's to illustrate the usage of TCP/UDP protocol.
2. Using any network simulation tool, simulate routing algorithms/congestion control

algorithms/network applications in traditional network/SDN/Adhoc Networks
3. Investigate network protocols by capturing and studying packets using Wireshark
4. SSH to coep.org.in and run a traceroute to google.com. List the results, then interpret and report your findings.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	1	1	-
CO 2	2	1	3	1	1	-
CO 3	2	1	3	1	1	-
CO 4	2	1	3	1	1	-
CO 5	3	3	3	2	1	1
CO 6	3	3	3	2	1	1

[PCC] Advanced Computer Architecture

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:
1. Understand the history, evolution, classifications and current trends of Computer Architecture; Learn to evaluate and compare the System's performance using standard benchmarks
2. Understand the basics of advanced microprocessor techniques and the salient features of state-of-the-art processors deployed in current High-Performance Computing systems
3. Understand the differences between System Area Networks and Storage Area Networks and learn the current Networking Technologies for implementing them
4. Learn the advanced RAID Levels, compare SAS vs SATA Disks & understand the implementation of a hierarchical Storage System as well as program the System Software Architecture, various parallel programming models, message passing paradigms & typical HPCC software stack

Unit 1: System Architecture [8 hrs]

History/Evolution, Definition: Hardware /Software Architecture, Flynn's Classification: SISD, SIMD, MISD, MIMD. Physical Models: PVP, MPP, SMP& Cluster of Workstations (COW). Memory Architectures: Shared, Distributed and Hybrid, UMA, NUMA, CC-NUMA. Performance Metrics and Benchmarks (Micro/Macro) Architectural Trends based on TOP 500 List of Supercomputers.

Unit 2: Advanced Microprocessor Techniques [8 hrs]

CISC, RISC, EPIC, Superscalar, Super-pipelined Architectures, Superscalar/ Super-pipelined, In Order Execution /Out of Order Execution (OOO), ILP, TLP, Power Wall, Moore's Law Redefined, Multicore Technologies, Intel's Tick-Talk Model. Study of State-of-the-art Processors: Intel / AMD X86-64 Bit Series: Intel Xeon Family (Xeon Haswell & Broadwell Architectures), Intel Xeon Phi Coprocessors (MIC Architecture) Intel/IBM Itanium/Power Series (Power 4 - Power 9). Introduction to Graphics Processing Units (GPU-NVIDIA).

Unit 3: System Interconnects **[4 hrs]**
SAN: System Area Networks, Storage Area Networks including InfiniBand, Gigabit Ethernet, Scalable Coherent Interface (SCI) Standard.

Unit 4: Storage **[4 hrs]**
Internal/External, Disk Storage, Areal Density, Seek Time, Disk Power, Advanced RAID Levels, SATA vs SAS Disks, Network Attached Storage (NAS), Direct Attached Storage (DAS), I/O Performance Benchmarks.

Unit 5: Software Architecture **[8 hrs]**
Parallel Programming Models: Message Passing, Data Parallel, MPI/PVM. Typical HPCC Software Stack including Cluster Monitoring Tools, Public Domain Software like GANGLIA, CUDA Programming Environment.

Unit 6: Case Studies **[8 hrs]**
A typical Peta Scale System based on Hybrid CPU/GPU Architectures, IBM SP System, C-DAC's latest PARAM Systems [PARAM Yuva-II], Sequent NUMA Q, Case Study of a Domain Specific Architecture (DSA).

Self Study:
Closely coupled and loosely coupled multiprocessor systems, Differences in RISC and CISC approaches, Differences in FAT and NTFS, Programs exhibiting Locality of Reference, Dependence analysis and hazard detection using different resources, Perf utility

Text Books

1. John L. Hennesy and David Patterson, Computer Architecture: A Quantitative Approach, 6th Edition, Elsevier, 2019
2. Kai Hwang and Zhiwei Xu, Scalable Parallel Computers, McGraw- Hill, 1998.
3. Data Manuals of respective Processors available at Website

Reference Book

1. Peter S. Pacheco, "An Introduction to Parallel Programming", Morgan Kaufmann, Elsevier Series, 2011, ISBN:978-0-12-374260-5.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	2	2	-
CO 2	3	1	3	2	2	-
CO 3	2	1	3	2	2	-
CO 4	2	1	3	2	2	-

[PEC] Distributed Operating Systems

Teaching Scheme	Examination Scheme
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 10 marks
Self-Study: 1 hour/week	ESE: 60 marks

Course Outcomes

Students will be able to:

1. Explain the characteristics and challenges of distributed systems.
2. Distinguish the design issues in distributed operating systems
3. Discuss RPC mechanisms, Distributed Shared Memory for inter process communication
4. Summarize the Synchronization issues in Resource and Process management, Process Migration, Distributed File System, etc

Unit 1: Fundamentals and Message Passing **[8 hrs]**

Fundamentals: Characteristics and challenges of distributed systems. Design issues in distributed operating systems; Architectural models, DCE. Message passing: Desirable features of good message passing systems, Issues in IPC by message passing; Synchronization, Buffering, Multi-datagram Messages, Encoding and decoding of message data, process Addressing, Failure Handling, Group Communication.

Unit 2: Remote Procedure Call **[7 hrs]**

RPC Model, Transparency of RPC, Implementing RPC mechanisms, RPC messages, Server management, parameter-passing semantics, call semantics Communication protocols for RPC, Client-Server Binding, RPC in Heterogeneous Environment.

Unit 3: Distributed Shared Memory and Synchronization **[7 hrs]**

General Architecture of DSM Systems, Design and Implementation issues in DSM, Consistency Models, Implementing Sequential Consistency Model, Page based distributed shared memory, shared – variable distributed shared memory, object-based distributed shared memory. Replacement Strategy, Thrashing, Heterogeneous DSM, Advantages of DSM, Synchronization: Clock Synchronization, Event Ordering, Mutual Exclusion, Deadlock, Election Algorithms.

Unit 4: Resource and Process Management [6 hrs]

Desirable features of good global scheduling algorithms, Task Assignment Approach, Load-Balancing Approach, Load-Sharing Approach, Process management: Process Migration, Threads.

Unit 5: Distributed File System and Naming **[6 hrs]**

File-Accessing Models, File-Sharing Semantics, File-caching Schemes, File Replication, Fault Tolerance, Atomic Transactions, Design Principles, Naming: Fundamental Terminologies and Concepts, System-Oriented names, Object-Locating Mechanisms, Human-Oriented names, Name cache, Naming and Security.

Unit 6: Security **[6 hrs]**

Potential Attacks to Computer Systems, Cryptography, Authentication, Access Control, Digital Signatures.

Text Book

1. Sinha P. K., Distributed Operating Systems Concepts and Design, PHI, 1997

Reference Book

1. Tanenbaum A. S., Distributed Operating Systems, Pearson Education India, 1995

Correlation between COs and POs

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	3	2	1	-
CO 2	2	-	3	2	1	-
CO 3	2	-	3	2	1	-
CO 4	2	-	3	2	1	-

[PEC] Artificial Intelligence

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Apply basic search techniques for problem solving.
2. Explain how to represent the Knowledge required for problem solving.
3. Apply reasoning to sift through data.
4. Utilize AI for application in real world.

Unit 1: **[6 hrs]**

Introduction: Artificial Intelligence, AI Problems, AI Techniques, The Level of the Model, Criteria For Success. Defining the Problem as a State Space Search, Problem Characteristics, Production Systems, Search: Issues in The Design of Search Programs, Un-Informed Search, BFS, DFS; Heuristic Search Techniques: Generate- And- Test, Hill Climbing, Best-First Search, A* Algorithm, Problem Reduction, AO*Algorithm, Constraint Satisfaction, Means-Ends Analysis

Unit 2: **[6 hrs]**

Knowledge Representation: Procedural Vs Declarative Knowledge, Representations & Approaches to Knowledge Representation, Forward Vs Backward Reasoning, Matching Techniques, Partial Matching, Fuzzy Matching Algorithms and RETE Matching Algorithms

Unit 3: **[6 hrs]**

Symbolic Logic: Propositional Logic, First Order Predicate Logic: Representing Instance and is-a Relationships, Computable Functions and Predicates, Syntax & Semantics of FOPL, Normal Forms, Unification &Resolution, Representation Using Rules, Natural Deduction; Structured Representations of Knowledge: Semantic Nets, Partitioned Semantic Nets, Frames, Conceptual Dependency, Conceptual Graphs, Scripts, CYC

Unit 4: **[6 hrs]**

Reasoning under Uncertainty: Introduction to Non-Monotonic Reasoning, Truth Maintenance

Systems, Logics for Non-Monotonic Reasoning, Model and Temporal Logics; Statistical Reasoning: Bayes Theorem, Certainty Factors and Rule-Based Systems, Bayesian Probabilistic Inference, Bayesian Networks, Dempster-Shafer Theory, Fuzzy Logic: Crisp Sets, Fuzzy Sets, Fuzzy Logic Control, Fuzzy Inferences & Fuzzy Systems

Unit 5: **[6 hrs]**
Natural Language Processing: Role of Knowledge in Language Understanding, Approaches Natural Language Understanding, steps in The Natural Language Processing, Syntactic Processing and Augmented Transition Nets, Semantic Analysis, NLP Understanding Systems; Planning: Components of a Planning System, Goal Stack Planning, Hierarchical Planning, Reactive Systems

Unit 6: **[6 hrs]**
Machine Learning: Knowledge and Learning, learning by Advise, Examples, learning in problem Solving, Symbol Based Learning, Explanation Based Learning, Version Space, ID3 Decision Based Induction Algorithm, Unsupervised Learning, Reinforcement Learning, Supervised Learning: Perceptron Learning, Back propagation Learning, Competitive Learning, Hebbian Learning.

Text Books

1. Artificial Intelligence, George F Luger, Pearson Education Publications
2. Artificial Intelligence, Elaine Rich and Knight, Mcgraw-Hill Publications

Reference Books

1. Introduction To Artificial Intelligence & Expert Systems, Patterson, PHI 2.
2. Weiss.G, Multi Agent systems- a Modern Approach to Distributed Artificial Intelligence, MIT Press.
3. Artificial Intelligence: A Modern Approach, Russell and Norvig, Prentice Hall

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	3	2	1	-
CO 2	2	-	3	2	1	-
CO 3	2	-	3	2	1	-
CO 4	2	-	3	2	1	-

[PEC] Advanced Graph Theory

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Prove theorems related to the concept of 'Matching' in graphs
2. Prove various results related to connectivity in graphs, network flows etc
3. Demonstrate familiarity with the results related to graph coloring
4. Demonstrate familiarity with special classes of graphs, algebraic graph theory and analytic graph theory

Unit 1: Matching and Factors **[8 hrs]**
Matchings in Bipartite Graphs, Hall's Matching Condition, Min-Max Theorems, Independent Sets, Tutte's 1-Factor Theorem, Maximum Bipartite Matching, Stable Matching, Dominating set and path cover, Gallai-Millgram theorem. Dilworth's theorem.

Unit 2: Connectivity and Paths **[6 hrs]**
Cuts and Connectivity, Flows in Directed Graphs, Connectivity: vertex connectivity, edge connectivity, 2-connected and 3-coonected graphs, Menger's theorem and its applications, Network flows: Min cut max flow theorem.

Unit 3: Graph Coloring **[6 hrs]**
Vertex coloring, Brook's theorem, Edge coloring, Planarity, 5-coloring planar graphs, Kuratowsky's theorem.

Unit 4: Special classes of graphs **[6 hrs]**
Perfect graphs, Interval Graphs, Chordal Graphs, Weak perfect graph theorem.

Unit 5: Algebraic Graph Theory **[6 hrs]**
Graphs and matrices, Automorphisms, Cayley Graphs, Spectral Graph Theory.

Unit 6: Analytic Graph Theory **[8 hrs]**
Extremal graph theory, Random Graphs, Ramsey theory, Probabilistic method.

Text Books

1. Douglas B. West, "Introduction to Graph Theory", Pearson Education India; 2nd edition (2015), ISBN-10: 9789332549654, ISBN-13: 978-9332549654
2. Béla Bollobás, Modern Graph Theory, Springer, 2013, ISBN-10: 9788181283092, ISBN-13: 978-818128309

Reference Books

1. Reinhard Diestel, Graph Theory, 4th edition (2010), ISBN-10: 3642142788,
2. a. ISBN-13: 978-3642142789
3. Adrian Bondy and U.S.R. Murty, "Graph Theory", Springer, 1st edition (2008), ISBN-10: 1846289696, ISBN-13: 978-1846289699

Internet Resource

1. NPTEL Course: https://nptel.ac.in/courses/106108054/

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	3	2	1	-
CO 2	2	-	3	2	1	-
CO 3	2	-	3	2	1	-
CO 4	2	-	3	2	1	-

[MLC] Research Methodology and Intellectual Property Rights

Teaching Scheme
Lectures: 2 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: CIE: 90 Marks, TA: 10 marks

Course Outcomes (COs):

Students will be able to

1. Understand research problem formulation and approaches of investigation of solutions for research problems
2. Learn ethical practices to be followed in research
3. Discover how IPR is regarded as a source of national wealth and the mark of economic leadership in the context of the global market scenario
4. Study the national & International IP system

Unit 1: **[5 hrs]**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, and necessary instrumentations.

Unit 2: **[5 hrs]**

Effective literature studies approaches, analysis Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype Analyze your results and draw conclusions or Build Prototype, Test and Redesign

Unit 3: **[5 hrs]**

Plagiarism, Research ethics Effective technical writing, how to write report, Paper.
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: **[4 hrs]**

Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights

Unit 5: **[7 hrs]**

Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting, Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

Unit 6: **[4 hrs]**

New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

Reference Books:

1. B L Wadehra, Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications, 2004
2. Satyawrat Ponkse, The Management of Intellectual Property, 1991.
3. Manual of Patent Office Practice and Procedure, 2019
4. W.H. Mayall, Industrial Design for Engineers, liffe Books, 1967
5. Niebel, Benjamin W, Product Design and Process Engineering, McGraw-Hill, 1974
6. Asimow, Morris, Introduction to Design, Prentice Hall, 1962

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	2	-	2
CO 2	3	3	-	2	-	2
CO 3	1	1	-	2	-	3
CO 4	1	1	-	2	-	3

[MLC] Effective Technical Communication

Teaching Scheme
Lectures: 1 hour/week
Self-Study: 1 hour/week

Examination Scheme
Theory: CIE: 90 Marks, TA: 10 marks

Course Outcomes (COs):

Students will be able to

1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts/principles of communication skills
4. To appreciate, analyze, and evaluate business reports and research papers

Unit 1: Fundamentals of Communication [4 hrs]

7 Cs of communication, common errors in English, enriching vocabulary, styles, and registers

Unit 2: Aural-Oral Communication [4 hrs]

The art of listening, stress and intonation, group discussion, oral presentation skills

Unit 3: Reading and Writing [4 hrs]

Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

Text Books

1. Raman Sharma, “Technical Communication”, Oxford University Press.
2. Raymond Murphy “Essential English Grammar” (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock “English Pronunciation in Use” Cambridge University Press.
4. Shirley Taylor, “Model Business Letters, Emails and Other Business Documents” (seventh edition), Prentice Hall
5. Thomas Huckin, Leslie Olsen “Technical writing and Professional Communications for Non-

native speakers of English", McGraw Hill.

Reference books/paper(s):

1. D.J.C. MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press
2. C. E. Shannon, A Mathematical Theory of Communication, Bell Sys. Tech Journ, 1948.

Web Resources:

1. NPTEL Course (Information Theory and Coding – IIT, Bombay): http://nptel.ac.in/syllabus/117101053/
2. MIT OpenCourseWare (Information Theory): http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-441- information-theory-spring-2010/index.htm

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	3	-	3	1	2
CO 2	-	3	-	3	1	2
CO 3	-	3	-	3	1	2
CO 4	-	3	-	3	1	2

[AEC] Mini Project/Seminar

Teaching Scheme	**Examination Scheme**
Laboratory: 2 hours/week	CIE: 50 marks,
Self-Study: 1 hour/week	ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Create links across different areas of knowledge and develop ideas to apply the problem-solving skills to a project task.
2. Do independent learning, and critical thinking and develop an attitude of innovation.
3. Identify a methodology for solving the project task and apply engineering knowledge to solve it
4. Communicate effectively and present ideas clearly in both written and oral forms.

Guidelines

Each student shall carry out a Mini Project task jointly in constant consultation with an internal guide assigned by the department. The project task may consider product development, prototype development, simulation development, statistical analysis, etc. The guide will continuously assess the progress of the work. Finally, a project report will be submitted as per the norms of avoiding plagiarism and the presentations will be taken.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	3	1	3	3
CO 2	2	2	3	1	3	3
CO 3	3	3	3	1	3	3
CO 4	3	3	3	1	3	3

Detailed Syllabus - Semester III

[OE] Data Structures

(offered to students of other departments)

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Decide appropriate data structures such as B-trees, heaps, etc that are best suits for solving a real-life problems
2. Implement advanced data structures, such as B-trees, multi-way trees, balanced trees, heaps, and priority queues, to solve computational problems
3. Analyze the time and space complexity of advanced data structures and their supported operations
4. Compare the time and space tradeoff of different advanced data structures and their common operations

Unit 1 **[6 hrs]**

Review of Basic Concepts: Abstract data types, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notations, Solving recurrence equations, Master theorems, Generating function techniques, Constructive induction.

Unit 2 **[8 hrs]**

Advanced Search Structures for Dictionary ADT: Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions.

Unit 3 **[6 hrs]**

Advanced Structures for Priority Queues and Their Extensions: Binary Heap, Min Heap, Max Heap, Binomial heaps, Leftist heaps, Skewed heaps, Fibonacci heaps and its amortized analysis, Applications to minimum spanning tree algorithms

Unit 4 **[6 hrs]**

Data Structures for Partition ADT: Weighted union and path compression, Applications to finite state automata minimization, Code optimization.

Unit 5 **[6 hrs]**

Graph Algorithms: DFS, BFS, Biconnected components, Cut vertices, Matching, Network flow; Maximum-Flow / Minimum-Cut; Ford–Fulkerson algorithm, Augmenting Path.

Unit 6 **[8 hrs]**

Computational Geometry: Geometric data structures, Plane sweep paradigm, Concurrency, Java Threads, Critical Section Problem, Race Conditions, Re-entrant code, Synchronization; Multiple Readers/Writers Problem.

Text Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction

to Algorithms, 3rd Edition, PHI Learning Pvt. Ltd.; ISBN-13: 978-0262033848 ISBN-10: 0262033844
2. Robert Sedgewick and Kevin Wayne, Algorithms, Pearson Education, 4th Edition, ISBN-13: 978-0321573513

Reference Books

1. S. Dasgupta, C.H. Papadimitriou, and U. V. Vazirani, Algorithms, McGraw-Hill, 2006; ISBN-13: 978-0073523408 ISBN-10: 007352340, 2
2. J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley, 2006; ISBN-13: 978-0321295354 ISBN-10: 0321295358

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	2	1	1	-
CO 2	3	-	2	1	1	-
CO 3	3	-	2	1	1	-
CO 4	3	-	2	1	1	-

[PCC&LC] Data Mining and Machine Learning

Teaching Scheme	**Examination Scheme**
Lectures: 3 hours/week	Theory: MSE: 30 Marks, TA: 10 marks
Labs: 2 hours/week	ESE: 60 marks
Self-Study: 1 hour/week	Laboratory: CIE: 50 marks,
	ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Apply and differentiate between supervised unsupervised and semi supervised algorithms
2. Estimate and evaluate model performance using advanced techniques such as Naïve Bayes, logistic Regression, Random Forest
3. Implement and analyze Data Mining algorithms for real-world problem solving
4. Apply data preprocessing techniques and evaluate their impact on model performance
5. Utilize and compare machine learning algorithms such as SVM, Random Forest, K- means for solving complex problems
6. Demonstrate the ability to critically analyze and improve machine learning models

Unit 1: Introduction **[6 hrs]**

Introduction to data mining, Applications, Motivation, Data mining knowledge discovery process, kinds of data, data mining techniques, issues in data mining Introduction to Machine Learning: What is machine learning, Applications of ML, Design Perspective and Issues in ML, Supervised, Unsupervised, Semi-supervised learning with applications and issues.

Unit 2: Input, Output and Data Pre-processing **[6 hrs]**

Input: Concepts, instances and attributes, Output: Knowledge Representation: Decision tables, Decision trees, Decision rules, Rules involving relations, Instance- based representation. Data Pre-processing-data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation.

Unit 3: Classification, Diagnostic and Prediction [8 hrs]
Introduction to Classification, issues regarding classification, Classification: Model (or hypothesis) representation, decision boundary, cost function, gradient descent, regularization.
Diagnostic: debugging a learning algorithm, evaluating a hypothesis (Model selection), training/validating/testing procedures (offline and online training of models), diagnosing bias versus variance and vice versa, and bias/variance, learning curves, regularization techniques
Accuracy and Error measures: classifier accuracy measures, predictor error measure, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, tradeoff between both, accuracy, Analysis of ROC, AUC.

Unit 4: Decision tree, Probabilistic classifier, Clustering [6 hrs]
Decision Tree: representation, hypothesis, issues in Decision Tree Learning, Pruning, Rule extraction from Tree, Learning rules from Data. Probabilistic classifier: Bayes rule, Maximum Likelihood Estimation, case study, Clustering: Unsupervised learning technique, Similarity and Distance Measures, k-means and k-medoids algorithm, optimization objective, random initialization, choosing value of k, EM algorithm.

Unit 5: Association Rule Mining and Support Vector Machines [6 hrs]
Mining Frequent Patterns, Associations and Correlations: Basic concepts, Apriori algorithm for finding frequent itemsets using candidate generation, generating association rules from frequent itemsets, from association to correlation analysis Support Vector Machines: Objective(optimization), hypothesis, SVM decision boundary, kernels: RBF and others.

Unit 6: Advanced Techniques [6 hrs]
Neural Networks, use case involving the use of neural network, role of various activation functions, SVD, Latent Dirichlet Allocation model, Latent Semantic Indexing, Models for Time-series forecasting - AR, MA, ARMA, ARIMA.

Text Books

1. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.
2. Jiawei Han Micheline Kamber, Data Mining Concepts and Techniques, Latest Edition

Reference Books

1. Ethem Alpaydin, Introduction to Machine Learning, PHI, 2005
2. D. Hand, H. Mannila and P. Smyth. Principles of Data Mining. Prentice-Hall. 2001
3. K.P. Soman, R. Longonathan and V. Vijay, Machine Learning with SVM and Other Kernel Methods, PHI-2009
4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006.
5. M. H. Dunham. Data Mining: Introductory and Advanced Topics. Pearson Education. 2001
6. Witten, E. Frank, Mark Hall, C. Pal. Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann. 2016
7. T. Fawcett, "An introduction to ROC analysis," *Pattern Recognit. Lett.*, vol. 27, no. 8, pp. 861–874, 2006. Link: https://people.inf.elte.hu/kiss/13dwhdm/roc.pdf

Suggested list of Assignments in the Laboratory:

1. Take any benchmark dataset (both numeric and text) and apply preprocessing techniques on it.

2. Compare the performance of 10 machine learning models for regression data set (eg. UCI repository Breast Cancer dataset) for the data partition of 70-30% with acceptable error of ±100. The comparative study of machine learning models should be of the form:

Model	Method	Package	r	R2	Error	Accuracy
M1						
M2						
…						
M10						

3. Study 5 feature selection techniques on the regression data set considered in (2) and report top five features. The study of feature selection techniques should be represented as :

Feature Selection Technique	Tops 5 Features
T1	
T2	
..	
T5	

4. Estimate the accuracy of the Naive Bayes classifier on the breast cancer data set using 5-fold cross-validation.
5. Implement the SVM algorithm with RBF. Estimate the precision, recall, accuracy, and F-measure on the text classification task for each of the 10 categories using 10-fold cross-validation of Reuters dataset.
6. Implement both the *k*-means algorithm and the Hierarchical Agglomerative Clustering (HAC) algorithm. For both, assume that all features are real-valued. Also assume that there is no need for normalization of the features. Use the L_n- norm for distance calculations with a default value of n=2 (Euclidean).
   Note that the datasets you are to test your algorithms with contain labeled items. You will need to ignore the label (target attribute, always last here) while clustering.
   Implement the *k*-means clustering algorithm and the HAC algorithm (using single linkage). For *k*-means, your program should automatically try $2 <= k <= 7$ and compute the squared error in each case. You should then return the value of k that produces the lowest squared error, together with that error. For HAC, you should compute (and store) the squared errors of all possible clustering's (as they are built from the bottom up). Upon completion, you should return the value of t (distance threshold) that produces the lowest squared error, the corresponding number of clusters, and the corresponding error.
   Use the algorithms on the Iris dataset(available on UCI repository) .
   Compare the best number of clusters obtained by *k*-means and HAC. How do these also compare with the underlying structure of the dataset in which there are 3 classes of iris plants?
   Experiment with your distance metric - can you find a value of n for the L_n-norm that changes the number of clusters found?
   Graph the value of the squared error for each clustering as HAC executes (with no threshold). What do you observe? Is this surprising?
7. Implement the Apriori algorithm. Build your own association task. Design your task so that it contains some simple associations you can check your algorithm against. List these associations. Run Apriori for various combinations of minsup and minconf values. Verify that the associations you designed into the task are discovered by your algorithm.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	3	2	3	-
CO 2	3	2	3	2	3	-
CO 3	3	2	3	2	2	-
CO 4	3	2	3	2	2	-
CO 5	3	2	3	2	3	-
CO 6	3	2	3	2	3	-

[PCC&LC] Security in Computing

Teaching Scheme
Lectures: 3 hours/week
Labs: 2 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks
Laboratory: CIE: 50 marks,
ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Demonstrate the importance of security in networked computing environments
2. Determine appropriate mechanisms such as encrypt, decrypt and transmit messages using cryptographic techniques for protecting networked systems.
3. Analyze vulnerabilities, threats and develop secure web based systems by implementing public key infrastructure mechanism
4. Discuss the issues concerning various threats to wireless networks, encryption and decryption
5. Analyze implementations of encryption techniques for time required to generate keys and encryption/decryption process also identify various possible attacks
6. Install and configure the open source tools used for proxy server, Firewall and IDS

Unit 1: Introduction [6 hrs]

Cryptography and Modern Cryptography, Basic concepts: threats, vulnerabilities, controls; risk; Security services, security policies, security mechanisms. Active vs. Passive attacks, Historical Ciphers and Their cryptanalysis, one-time passwords (Vernam's Cipher)

Unit 2: Number Theory [6 hrs]

Review of number theory and algebra, computational complexity, probability and information theory, primality testing, the Euclidean algorithm – Congruences: Definitions and properties – linear congruences, residue classes, Euler's phi function – Fermat's Little Theorem – Chinese Remainder Theorem

Unit 3: Symmetric Key Encryption [7 hrs]

Cryptography and cryptanalysis, DES, Triple DES, AES, IDEA, CAST-128, RC4, Modes of operation, Message Authentication Codes (MAC), Message Digest algorithms, Secure Hash Algorithm

Unit 4: Public Key Cryptography and Digital Signature **[7 hrs]**
RSA cryptosystem, Key Management Protocols, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography (ECC), ElGamal Algorithm, Digital Certificate, X.509 Certificate Standard, Algorithms for Digital Signature, Digital Signature Standards, Authentication Methods, Kerberos

Unit 5: IP and Web Security **[6 hrs]**
IP Security Architecture, IPsec, IPv4, IPv6, Authentication Header Protocol, Encapsulating Security Payload Protocol, VPN, Pretty Good Privacy (PGP), MIME, S/MIME, Secure Socket Layer (SSL), Secure Electronic Transaction (SET) Transport Layer Security (TLS), Secure Hyper Text Transfer Protocol (SHTTP)

Unit 6: Wireless Network Security **[6 hrs]**
Wireless Attack: Surveillance, War Driving, Client-to-Client Hacking, Rogue Access Points, Jamming and Denial of Service. Wireless availability, Privacy Challenges, Risks: Denial of Service, Insertion Attacks, interception and monitoring wireless traffic, Mis-configuration. Access Point-Based Security Measures, Thin Party Security Methods

Text Books:

1. William Stallings, Cryptography and Network Security, Prentice Hall, 4th Edition, 2006
2. Behrouz A Forouzan, Cryptography & Network Security, McGraw-Hill, 2008
3. Atul Kahate, Cryptography and Network Security, Tata McGraw-Hill, 2nd Edition, 2008.
4. William Stallings, Network Security Essentials Applications and Standards, Pearson Education, New Delhi.

References:

1. C. Pfleeger and S. Pfleeger, Security in Computing, Prentice Hall,4th Edition, 2007.
2. Eric Maiwald, Fundamentals of Network Security, McGraw-Hill, 2004.
3. Jay Ramachandran, Designing Security Architecture Solutions, Wiley Computer Publishing, 2002.
4. Bruce Schneier, Applied Cryptography, John Wiley & Sons Inc, 2001.
5. Charlie Kaufman, Radia Perlman and Mike Speciner, Network Security Private Communication in a public world, Prentice Hall of India Private Ltd., New Delhi

Suggested list of assignments in the Laboratory:
1. Design and implement your own encryption/ decryption algorithm using any programming language
2. Design an experiment to estimate the amount of time to generate a key pair (RSA): Encrypt n bit message (RSA), Decrypt n bit message (RSA), as a function of key size, and experiment with different n-bit messages. Summarize your conclusion.
3. Implementation of email security using PGP (create yourself a 1024-bit PGP key. Use your name and email address for your key label. Use PGP to verify the signature on this assignment.
4. Install any Proxy Server and configure an application gateway.
5. Install any Firewall and configure it as per the defined security policy.
6. Install, Configure and study any Intrusion Detection System (IDS).

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	-	2	3
CO 2	3	3	2	-	3	2
CO 3	3	-	3	1	2	1
CO 4	3	3	2	-	3	2
CO 5	3	1	2	2	3	-
CO 6	3	1	2	-	3	-

[PCC&LC] Embedded Systems

Teaching Scheme
Lectures: 3 hours/week
Labs: 2 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks
Laboratory: CIE: 50 marks,
ESE (Orals): 50 Marks

Course Outcomes

Students will be able to:

1. Explain Characteristics and recent trends in Embedded Systems
2. Discuss PIC and ARM families
3. Explain the communication interface for wired and wireless protocols
4. Design a system using the concepts of RISC architecture and ARM processors
5. Decide the hardware and/or software components best suited for a given problem taking into consideration constraints such as cost, performance etc.
6. Develop prototype codes using commonly available on and off chip peripherals with and without interrupts on Cortex M3/M4 development boards

Unit 1: Overview of Embedded Systems **[4 hrs]**

Introduction, Definition, Characteristics & Salient Features, Classification, Application Areas, Overview of Embedded System Architecture & Recent Trends.

Unit 2: Hardware Architecture **[8 hrs]**

Embedded Hardware based on Microprocessors, Microcontrollers & DSPs. Study of PIC Microcontrollers: PIC16C6X/7X Family & Applications. Study of ARM Family: ARM 7,9,10 &11: Overview & Architecture Comparison, Detailed Study of ARM7-TDMI including Core Architecture, ARM/Thumb State, On-Chip Debug and Development Support, AMBA Bus, Applications.

Unit 3: Communication Interface **[6 hrs]**

Serial, Parallel, Wired Wireless Protocols Wired: CAN, I2C, USB, FireWire Wireless: BlueTooth, IrDA, IEEE802.11.

Unit 4: Software Architecture **[6 hrs]**

Concepts: Embedded OS, Real-Time Operating Systems (RTOS), Detailed Study of RT Linux, Hand Held OS, Windows CE. & Development Tools.

Unit 5: Embedded Systems for Automotive Sector **[6 hrs]**
Electronic Control Units (ECU) for Engine Management, Antilock Braking System (ABS), Crusie Control, Design Challenges, Legislative Emission Norm, Interface Standards, Developmental Tools Navigation Systems: Global Positioning System (GPS): Detailed Study and Applications.

Unit 6: **[4 hrs]**
Smart Cards: Classifications, Interfacing, Standards & Applications. RFID Systems: Technology, RFID Tag, RFID Reader, Applications.

Unit 7: Case Studies **[6 hrs]**
Embedded System for Mobile Applications, DSP Based Embedded System, Networked Embedded System and Digital Camera.

Text Books

1. K.V.K. Prasad, Embedded / Real Time Systems: Concepts, Design and Programming Black Book, Dreamtech Press, 2005.

Reference Books

1. Vahid F. and Givargies T., Embedded Systems Design, John Wiley X. Sons, 2002
2. John B Peatman, Design with PIC Microcontrollers, Pearson Education, 1998
3. Liu, Real-Time Systems, Pearson Education, 2000.
4. Technical Manuals of ARM Processor Family available at ARM Website on Net

Suggested list of Assignments in the Laboratory:

Experiments to be carried out on Tiva (TM4C123X) Launch-pads:

1. Blink an LED with software delay, delay generated using the SysTick timer.
2. System clock real time alteration using the PLL modules.
3. Control intensity of an LED using PWM implemented in software and hardware.
4. Control an LED using switch by polling method, by interrupt method and flash the LED once every five switch presses.
5. Key matrix and alphanumeric LCD interfacing and programming.
6. UART programming with accessing TX ad RX buffers directly and using DMA.
7. Recording of analog readings at the output of rotary potentiometer connected to ADC channel.
8. Programming (ISL 29023) Ambient and Infrared Light sensor available on Sensor Hub Booster Pack using I^2C interface.
9. Calling C functions from assembly programs and vice versa.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	3	1	1	-
CO 2	2	2	3	1	1	-
CO 3	2	2	3	1	1	-
CO 4	2	2	3	1	1	-
CO 5	2	3	3	1	1	3
CO 6	2	3	3	1	1	3

[PEC] Cloud Computing and Virtualization

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Characterize the distinctions between various cloud models and services and compare the functioning and performance of virtualization of CPU, memory and I/O with traditional systems
2. Familiar with cloud platforms and technologies like AWS, vSphere etc.
3. Create a cloud infrastructure after learning OpenStack components
4. Analyze the security risks associated with virtualization, cloud computing and evaluate how to address them

Unit 1 **[6 hrs]**

Introduction: Benefits and challenges to Cloud architecture, Cloud delivery models- SaaS, PaaS, LaaS. Cloud Deployment Models- Public Cloud, Private Cloud, Community Cloud and Hybrid Cloud, Service level agreements in clouds, case Studies on Cloud services, Cloud Adoption Challenges.

Unit 2 **[8 hrs]**

Virtualization: Role of virtualization in enabling the cloud, Levels of Virtualizations, Types of Virtualization: Compute, Network and Storage Virtualizations, Virtual Machine, Hypervisor: Type 1 and 2, Examples of Hypervisors.

Server Virtualization: X86 architecture, Protected mode, Rings of Privileges, Virtualization challenges, Full virtualization and Binary Translation, Ring De-Privileging, Handling Sensitive instructions, ESXi, Para-Virtualization, Xen, Hardware Assisted Virtualization, System call and hardware interrupts handling in virtualized systems, Intel VTx, KVM, VM Migration

Unit 3 **[8 hrs]**

Memory and I/O Virtualization: Memory management and I/O with traditional OS, Challenges in virtualized system, Shadow page Tables in Full Virtualized system, EPT/NPT, 2D Page walks, I/O in Virtualized Systems, Emulation, Split drivers of Xen, Direct I/O, Intel VTd, VMCS

Unit 4 **[6 hrs]**

Cloud Orchestration: Elements of Cloud Orchestration, Examples platforms: OpenStack and vSphere, OpenStack Deep dive: Covers Networking, Storage, Authentication modules of OpenStack, Nova, Quantum, Keystone and Cinder, Swift.

Unit 5 **[4 hrs]**

Cloud Platforms: Overview and Architecture, Azure, Google App Engine, Amazon Web Services.

Unit 6 **[8 hrs]**

Virtualization Security: Security Challenges Raised by Virtualization, Virtualization Attacks, VM Migration Attacks, Launch Pad for Brute Force attacks, Security Solutions, Hypervisor-Based

Segmentation, case studies of Hypervisors.
Cloud Security: Issues with Multi-tenancy, Isolation of users/VMs from each other, VM vulnerabilities, hypervisor vulnerabilities, VM migration attacks, Cloud based DDoS, Developing cloud security models, end-to-end methods for enforcing Security, Security policies and programming models with privacy-aware APIs

Text Books

1. Kai Hwang, Geoffrey and KJack, Distributed and Cloud computing, Elsevier, 2011
2. Shailendra Singh, Cloud Computing, Oxford Higher Education, 2018

Reference Books

1. Danielle Ruest and Nelson Ruest, Virtualization, A beginners Guide, Tata McGraw Hill,2009
2. Tom White, Hadoop: The Definitive Guide, O'REILLY, 3rd Edition, 2012
3. Dinakar Sitaram and Geetha Manjunath, Moving to the cloud, Elsevier, 2012

On-line Course Resources

1. Understanding Full Virtualization, Para Virtualization and Hardware Assist, VMware White paper
2. AMD-V Nested Paging, white paper, July 2008
3. Patent: US 8533428 B2, Translating a Guest Virtual Address to a Host Physical Address as Guest Software Executes on a Virtual Machine, 2013
4. Darren Abramson, et. all, Intel Virtualization Technology for Directed I/O, Intel Technology Journal, Vol. 10, Issue 3, 2006
5. Uhlig, R., et al., "Intel Virtualization Technology", IEEE Computer Society, 38(5), pp 48-56, 2005
6. "OpenStack Docs: Current", http://docs.openstack.org/
7. " vSphere 5 Documentation Center: ",http://pubs.vmware.com/vsphere- 50/index.jsp
8. "Google App Engine", https://developers.google.com/appengine/
9. "Windows Azure: Microsoft's Cloud Platform| Cloud hosting |Cloud Service ", http://www.windowsazure.com/en-us/
10. Hadoop Performance Tuning, Impetus Technologies Inc., October 2009

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	3	2	1	-
CO 2	3	-	3	3	1	-
CO 3	3	-	3	2	1	-
CO 4	3	-	3	3	1	-

[PEC] Natural Language Processing

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Demonstrate the understanding of basic text processing techniques in NLP.
2. Design, implement and evaluate part-of-speech taggers and parsers for a language.
3. Build language models and demonstrate Word Sense Disambiguation using WordNet.
4. Analyze and build word embeddings for different languages.

Unit 1: Introduction **[6 hrs]**

What is NLP, Fundamental and Scientific goals, Engineering goals, stages of NLP, problems in NLP, Applications of NLP, Empirical Laws of language, zipf's law, Heap's law.

Unit 2: Basic Text Processing **[8 hrs]**

Tokenization, word token, word type, sentence segmentation, feature extraction, issues in tokenization for different languages, word segmentation, text segmentation, normalization, case folding, Spelling Correction, Morphology, Stemming, Porters Algorithm, , lemmatization, spelling correction - dynamic programming approach for finding edit distance, N-gram Language Modeling- context sensitive spelling correction, probabilistic language model, auto completion prediction, Evaluation and perplexity, Smoothing techniques.

Unit 3: POS Tagging **[8 hrs]**

Sequence labeling tasks of NLP, POS tagging, POS tag sets, Hidden Markov Model- Introduction, Markov Processes, HMM characterization -Likelihood of a sequence (Forward Procedure, Backward Procedure), Best state sequence (Viterbi Algorithm), Re-estimation(Baum-Welch - Forward-Backward Algorithm) , Models for Sequential tagging – Maximum Entropy, Conditional Random Field.

Unit 4: Syntax **[10 hrs]**

Constituency and dependency parsing, Constituency parser -Syntactic structure, Parsing methodology, Different parsing algorithms, Parsing in case of ambiguity, Probabilistic parsing, CKY algorithm, Issues in parsing, Dependency parsing- Syntactic structure, Parsing methodology, Transition-Based Dependency Parsing, Graph-Based dependency parsing, Evaluation, Co-reference resolution, Named-entity recognition.

Unit 5: Knowledge Base and Semantics **[6 hrs]**

WordNet: Word Senses, Word relations, Word similarity and thesaurus methods, Word sense disambiguation, WordNet. Lexical and Distributional Semantics - Introduction, models of semantics, applications.

Unit 6: Word Embeddings **[6 hrs]**

Introduction, one-hot vectors, methods of generating word embeddings, Skip-gram, CBOW, Glove model, Fast Text model, evaluation measures-rough scores.

Text Books

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", Second Edition, Prentice Hall, 2008, ISBN: 978-0131873216.
2. Allen James, "Natural Language Understanding", Second Edition, Benjamin/Cumming, 1994, ISBN: 978-0805303346.
3. Chris Manning and Hinrich Schuetze, "Foundations of Statistical Natural Language Processing", MIT Press, ISBN: 978-0262133609.

Reference Books

1. Journals: Computational Linguistics, Natural Language Engineering, Machine Learning, Machine Translation, Artificial Intelligence.
2. Conferences: Annual Meeting of the Association of Computational Linguistics (ACL), Computational Linguistics (COLING), European ACL (EACL), Empirical Methods in NLP (EMNLP), Annual Meeting of the Special Interest Group in Information Retrieval (SIGIR), Human Language Technology (HLT).

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	-	3	2	1	-
CO 2	3	-	3	3	1	-
CO 3	3	-	3	2	1	-
CO 4	3	-	3	3	1	-

[PEC] Parallel Algorithms

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week
End-Sem Exam – 60 marks

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Demonstrate familiarity with various algorithm design paradigms
2. Analyze algorithms based on different paradigms
3. Decide which paradigm suits best to solve a real-life problem under given constraints/resources
4. Implement and test representative algorithms based on different techniques

Unit 1: Computational Geometry **[8 hrs]**

Convex hull, Closest pair of points, Line segment intersection

Unit 2: Approximation Algorithms **[8 hrs]**

Vertex cover problem, Traveling Salesperson problem, Set covering problem

Unit 3: Randomized Algorithms **[8 hrs]**

Quick sort, Max-cut algorithm, Primality Testing

Unit 4: Parallel Algorithms **[8 hrs]**

Theoretical models of parallel computation: variants of the PRAM model, Performance of parallel algorithms, Quick sort, Bitonic sort

Unit 5: Streaming Algorithms **[8 hrs]**

Finding frequent items deterministically, Estimating the number of distinct elements, Finding frequent items via Sketching, Estimating frequency moments

Text Books

1. Thomas Cormen, Charles Leiserson, Ronald Rivest and Cliford Stein, Introduction to Algorithms, PHI, 2009
2. Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, Mining of Massive Datasets, Dreamtech Press, 2023

Reference Books

1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 1995
2. Vijay V. Vazirani, Approximation Algorithms, Springer, 2001

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	2	1	1	1
CO 2	2	2	2	1	1	-
CO 3	1	1	2	1	-	-
CO 4	1	1	2	1	-	-

[PEC] Advanced Compiler Construction

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Demonstrate familiarity with the design of a typical compiler
2. Demonstrate familiarity with the compiler intermediate representation.
3. Demonstrate familiarity with code optimization techniques
4. Demonstrate familiarity with the issues and techniques related to data flow analysis and register allocation

Unit 1: Introduction [6 hrs]

Review of Compiler Structure, Advanced Issues in Elementary Topics, Importance of Code Optimization, Structure of Optimizing Compilers, Placement of Optimizations in Aggressive Optimizing Compilers

Unit 2: Context –Sensitive Analysis & Intermediate Representation [6 hrs]

Introduction to type systems, The Attribute –grammar framework, Adhoc Syntax directed translation, Harder problems in type inference and changing associativity, Issues in designing an intermediate languages, Graphical & Linear IR, Static-single Assignment form, Mapping values to names & symbol tables.

Unit 3: Code Optimization [8 hrs]

Introduction, Redundant expressions, Scope of optimization, Value numbering over regions larger than basic blocks, Global redundancy elimination, Cloning to increase context, Inline substitution, Introduction to control flow analysis, Approaches to control flow analysis, Interval analysis and control trees, Structural analysis, Reaching definitions.

Unit 4: Data Flow Analysis & Scalar Optimization **[10 hrs]**
Basic concepts : Lattices, flow functions and fixed points, Iterative data flow analysis, Lattice of flow functions, Control –tree based data flow analysis, Structural analysis and interval analysis, Static Single Assignment (SSA) form, Dealing with arrays, structures and pointers, Advanced topics: Structures data-flow algorithms and reducibility, Inter procedural analysis (Control flow, data flow, constant propagation, alias), Inter procedural register allocation, Aggregation of global references, Introduction to scalar optimization, Machine –independent and dependent transformations, Example optimizations (eliminating useless and unreachable code, code motion, specialization, enabling other transformation, redundancy elimination)., Advanced topics (Combining optimizations, strength reduction).

Unit 5: Instruction Selection & Scheduling **[8 hrs]**
Introduction, Instruction selection and code generation via Sethi Ullman, Aho Johnson algorithm, Instruction selection via tree-pattern matching, Instruction selection via peephole optimization, Learning peephole patterns, Generating instruction sequences, Introduction to instruction scheduling, The instruction scheduling problem, List scheduling, Regional scheduling.

Unit 6: Register Allocation **[6 hrs]**
Introduction, Issues in register allocation, Local register allocation and assignment, Moving beyond single block, Global register allocation and assignment, Variations on Graph Coloring Allocation, Harder problems in register allocation, CASE Study of GCC compiler.

Text Books

1. Keith D. Cooper and Linda Torczon, Engineering a Compiler, Elsevier-Morgan Kaufmann Publishers, 2004.
2. Steven S. Muchnick, Advanced Compiler Design Implementation, Elsevier- Morgan Kaufmann Publishers, 2003.
3. Uday Khedker, Amitabha Sanyal, Bageshri Karkare, Data Flow Analysis: Theory and Practice, CRC Press, 2009

Reference Books

1. Andrew Appel, Modern Compiler Implementation in C: Basic Techniques, Cambridge University Press, 1997.
2. Y.N. Srikant, Priti Shankar, The Compiler Design Handbook: Optimizations and Machine Code Generation, CRC Press, 2nd Edition, 2002.
3. David R. Hanson, Christopher W. Fraser, A Retargetable C Compiler: Design and Implementation, Addison-Wesley, 1995
4. Morgan, Robert, Building an Optimizing Compiler, Digital Press Newton, 1998.
5. John Levine, Tony Mason & Doug Brown, Lex and Yacc, O'Reilly

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	1	2	1
CO 2	2	1	3	2	2	1
CO 3	2	2	3	1	2	1
CO 4	2	2	3	1	2	1

[PEC] Deep Learning

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Understand the fundamentals of neural networks.
2. Design feed-forward networks with backpropagation.
3. Apply attention mechanism to the neural network.
4. Solve the real-time problem statements using Deep Learning Architectures

Unit 1: Basics **[4 hrs]**

Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.

Unit 2: Feedforward Networks **[6 hrs]**

Introduction to the neural network and multilayer perceptron (MLPs) representation power of MLPs, sigmoid neurons, gradient descent, feed-forward neural networks representation, Backpropagation.

Unit 3: Optimization Techniques **[8 hrs]**

Gradient Descent, Batch Optimization, Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).

Unit 4: Autoencoders **[10 hrs]**

Autoencoders, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

Unit 5: Convolutional Neural Networks (CNN) **[8 hrs]**

Introduction to CNN, Building blocks of CNN, Transfer Learning, LeNet, AlexNet, ZF- Net, VGGNet, GoogLeNet, ResNet, Visualizing CNNs, Guided Backpropagation,
Fooling Convolutional Neural Networks.

Unit 6: Recurrent Neural Networks (RCNN) **[4 hrs]**

Introduction to RCNN, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT

Self Study: **[4 hrs]**

Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs, Encoder Decoder Models, Attention Mechanism.

Text Book

1. Ian Goodfelllow, Yoshua Benjio and Aaron Courville, Deep Learning, The MIT Press, 2016.
2. François Chollet, Deep Learning with Python, Manning, Second Edition, 2021.
3. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, O'Reilly Media, Inc., 2017.

Reference Books

1. Raúl Rojas, Neural Networks: A Systematic Introduction, Springer, 1996.
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	3	1	2	-
CO 2	2	2	3	1	2	-
CO 3	2	2	3	1	2	-
CO 4	2	2	3	1	2	2

[PEC] Multicore Technology

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1 hour/week

Examination Scheme
Theory: MSE: 30 Marks, TA: 10 marks
ESE: 60 marks

Course Outcomes

Students will be able to:

1. Understand the working principles of multicore architectures.
2. Optimize performance of multicore systems.
3. Specify the necessity of GPU.
4. Comprehend and differentiate between CPU and GPU. Identify and demonstrate the need of domain specific architectures.

Unit 1: Introduction to Multicore Systems: [5 hrs]

Fundamentals, The Era of Multicore Machines, Unicore vs Multicore - Understanding Performance - Shared Memory Multicore Systems - Distributed Memory Multicore Systems - Hybrid Systems - Symmetric and Asymmetric Multicore Systems – Overview of Multithreading – Multithreading in different forms – Homogeneous and Heterogeneous Multicore systems – Examples of different Multicore Systems.

Unit 2: Cache Memory: [7 hrs]

Large Cache Design: Shared vs. Private Caches - Centralized vs. Distributed - Shared Caches – Coherence: Snooping-based cache coherence protocol, directory-based cache coherence protocol - Uniform Cache Access, Non-Uniform Cache Access - S- NUCA, D-NUCA - Inclusion, Exclusion – Examples of different Cache Organization - Consistency Models – Case Study.

Unit 3: Performance and Optimizations for Multicore Systems: [5 hrs]

Select the right "core" - Improve serial performance - Achieve proper load balancing - Improve data locality - Reduce or eliminate false sharing - Use of affinity scheduling - Lock granularity and frequency - Remove synchronization barriers - Minimize communication latencies - Use of thread pools - Managing thread count - Use of parallel libraries.

Unit 4: Programming Multicore Systems: [8 hrs]
Programming models for Multicore Systems – Shared Memory Programming using pthreads - Shared Memory Programming using OpenMP – Use of OpenMP compiler directives – #pragma with different clauses – Understanding parallelized loops – Synchronization Constructs towards dependencies – Function parallel program - OpenMP Library Functions, OpenMP Environment Variables, Compilation, Debugging, Performance.

Unit 5: Special Case – Graphics Processing Unit: [9 hrs]
CPU architecture - GPU hardware – CPU and GPU: Design Goals – Compute levels – Case Study: Nvidia GPU – GPGPU - Compute Unified Device Architecture (CUDA) Programming model – Applications of CUDA - Threads, Blocks, Grids – Memory management – Examples – Alternatives to CUDA.

Unit 6: Domain Specific-Architectures: [6 hrs]
Guidelines for domain specific architectures – Deep Learning Architecture - Google's Tensor Processing Unit (TPU) for Deep Neural Networks (DNNs) - Pixel Visual Core, a Personal Mobile Device Image Processing Unit.

Self Study:
Open source simulators, OpenMP clauses, pyCUDA syntax, OpenACC syntax and differences with normal executions. Intel Core i7, i9 and AMD Ryzen7 specifications and differences.

Text Books and Research Papers

1. Gerassimos Barlas, Multicore and GPU Programming: An Integrated Approach, Morgan Kaufmann, 2015.
2. Rob Oshana, Multicore Application Development Techniques: Applications, Tips and Tricks, Elsevier, 2016.
3. John L Hennessy, David A Patterson, Computer Architecture: A Quantitative Approach, Sixth Edition, Morgan Kaufmann, 2018.

Reference Books

1. Rajeev Balasubramanian, Norman P. Jouppi, and Naveen Muralimanohar, Multi-Core Cache Hierarchies, Morgan and Claypool Publishers, 2011.
2. Daniel J. Sorin, Mark D. Hill, David A. Wood A Primer on Memory Consistency and Cache Coherence, Morgan & Claypool Publishers, 2011.
3. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Morgan Kaufmann, 2013.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	3	3	1
CO 2	3	3	3	2	3	1
CO 3	2	3	3	3	3	-
CO 4	3	3	3	3	3	1

[CCA] Liberal Learning Course

Teaching Scheme
Lectures: 1 hour/week

Examination Scheme
CIE: 90 marks, TA: 10 marks

Guidelines:

Liberal Learning Courses began aims with a vision of expanding the horizons of knowledge in a variety of areas beyond Engineering. It provides opportunities to students of Engineering to foray into areas of their interest, to contribute to their overall personality development. The students are required to go through the areas of agriculture, Clay Art & Pottery, Dance (Contemporary), Dance (Indian), Film Appreciation, French, Geography, Holistic Health, Interior Design, Introduction to Indian Armed Forces, Music (Instrumental), Music (Vocal), Painting, Photography, Political Science, Theatre & Dramatics, Wood & Metal Art etc. Experts from respective areas conduct classes for each area on campus through activities, discussions, presentations, and lecture methods, and an evaluation out of 100 per area is done for each area throughout the semester. Evaluation patterns may differ according to the nature of each area. Although there is no pre-defined syllabus for LLC areas, there is an outline that experts normally develop and follow for the classes. However, students may approach the faculty to cover certain topics of their interest in that area during classes based on students' interests and experts' areas of expertise.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	-	2	2	-
CO 2	-	2	-	2	2	-
CO 3	-	2	-	2	2	-
CO 4	-	2	-	2	2	-

Detailed Syllabus: Semester III

[SLC] Massive Open Online Course – I

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1hour / Week

Examination Scheme
Theory: CIE: 40 Marks
ESE: 60 marks

Course Outcome
Students will able to:
1. Acquire new skills or knowledge to enhance their personal and professional development
2. Receive a flexible learning environment, allowing one to study at own pace and convenience
3. Opportunity for lifelong learning
4. Foster collaboration and networking among participants

The students in consultation with the faculty advisor opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL. For the students who secured a passing score in the NPTEL examination, the marks obtained for assignments (in 25 marks) will be upscaled to out of 40 marks of CIE and the marks obtained from the certificate examination (in 75 marks) will be downscaled 60 marks of ESE assessments.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	3	2	3	-
CO 2	2	2	3	2	3	-
CO 3	2	2	3	2	3	-
CO 4	2	2	3	2	3	-

[SLC] Massive Open Online Course – II

Teaching Scheme
Lectures: 3 hours/week
Self-Study: 1hour / Week

Examination Scheme
Theory: CIE: 40 Marks
ESE: 60 marks

Course Outcome
Students will able to:
1. Acquire new skills or knowledge to enhance their personal and professional development
2. Receive a flexible learning environment, allowing one to study at own pace and convenience
3. Opportunity for lifelong learning
4. Foster collaboration and networking among participants

The students in consultation with the faculty advisor opt for a single course of 12 weeks offered by the NPTEL in the current semester. The students need to register for the examination conducted by the NPTEL. For the students who secured a passing score in the NPTEL examination, the marks obtained for assignments (in 25 marks) will be upscaled to out of 40 marks of CIE and the marks obtained from the certificate examination (in 75 marks) will be downscaled 60 marks of ESE assessments.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	2	3	2	3	-
CO 2	2	2	3	2	3	-
CO 3	2	2	3	2	3	-
CO 4	2	2	3	2	3	-

[VSEC] Dissertation Phase – I

Teaching Scheme
Laboratory: 12 hours/week
Self-Study: 18 hour / Week

Examination Scheme
Theory: CIE: 50 Marks
ESE: 50 marks

Course Outcomes

Students will be able to:

1. Demonstrate how to search the existing literature to gather information about a specific problem or domain.
2. Identify the state-of-the-art technologies and research in the chosen domain, and highlight open problems that are relevant to societal or industrial needs.
3. Evaluate various solution techniques to determine the most feasible solution within given constraints for the chosen dissertation problem.
4. Apply software engineering principles related to requirements gathering and design to produce relevant documentation.
5. Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.
6. Deliver effective oral presentations to communicate the findings and outcomes of the research work.

Guidelines

The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

Student is expected to complete the following activities in Phase-I:

1. Literature survey
2. Problem Definition
3. Motivation for study and Objectives
4. Preliminary design / feasibility / modular approaches

Deliverables

1. A report having following details: Abstract, Problem statement, Requirements specification, Literature survey, Proposed solution, High level design description, Plan for implementation

and testing in Phase-II
2. A presentation that covers the major points covered in the report.
3. A proof of concept (preferable but not mandatory)

Evaluation

Two independent assessments (Mid-Semester and End-Semester evaluations) will be done:

1. The internal guide will evaluate his/her student for 40 marks
2. A panel of External Examiner(s) and two senior faculty of the department will evaluate the work for 60 marks

The marks obtained in these two assessments will be combined to get final evaluation out of 100 marks. The course grading, like other courses, will be relative in nature.

The evaluation will take place based on criteria such as literature survey and well-defined project problem statement, proposed high level system design, concrete plan for implementation and result generation, presentation etc.

The panel (external examiner(s) and senior faculty) will provide a report about suggestions/changes to be incorporated during phase-II.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	3	3	2	2
CO 2	3	3	3	2	2	2
CO 3	3	3	3	2	2	2
CO 4	2	3	2	2	2	3
CO 5	2	3	2	2	2	3
CO 6	2	3	2	2	2	3

Detailed Syllabus: Semester IV

[VSEC] Dissertation Phase – II

Teaching Scheme	**Examination Scheme**
Laboratory: 24 hours/week	Theory: CIE: 50 Marks
Self-Study: 12 hour / Week	ESE: 50 marks

Course Outcomes

Students will be able to:

1. Achieve proficiency in the languages, tools, libraries, and technologies used in the dissertation work.
2. Apply project planning principles and techniques to ensure effective and efficient project execution.
3. Demonstrate an understanding of the entire lifecycle of a software product or solution.
4. Produce artifacts such as source code, test plans, and test results based on the dissertation work.
5. Write research paper(s) and a thesis in accordance with publication ethics.
6. Exhibit the presentation skills needed to effectively present the work at various platforms.

Guidelines

Student is expected to complete the following activities in Phase-II:

1. Implementation of the proposed approach in the first stage
2. Testing and verification of the implemented solution
3. Writing of a report and presentation
4. Publish the work done at suitable conference/in a journal

Deliverables

1. Source code (if the project is in-house)
2. Dissertation report that gives overview of the problem statement, literature survey, design, implementation details, testing strategy and results of testing
3. All the artifacts created throughout the duration of dissertation such as requirements specification, design, project plan, test cases etc
4. Presentation based on the dissertation report
5. Research Paper(s) based on the dissertation work

Evaluation

Evaluation will be done in two steps: Mid-Semester evaluation and End-Semester evaluation.

- Mid-Semester evaluation:

Evaluation will be done by the internal guide and a qualified external examiner The internal guide will evaluate his/her student for 20 marks.
External Examiner will provide evaluation for 30 marks

The assessment is done on the criteria such as concrete system design, implementation status and concrete plan for completion of remaining tasks, presentation etc.

The purpose of Mid-Semester evaluation is also to check preparedness of students for the End-Semester evaluation. Examiners may give suggestions for changes/corrections to be incorporated before the final evaluation. If the work done till then may not lead to successful completion of the dissertation in the remaining time, student may be asked to take extension in time to complete the course.

- End-Semester evaluation:

The internal guide and one external examiner will carry out the final evaluation. The guide will provide evaluation for 20 marks and the external examiner for 30 marks.

The assessment will be done based on the criteria such as quality of implementation, result analysis, project outcomes (publications, patent, copyright, contribution to opensource community, participation in project competition etc.), quality of report, presentation etc.

The total assessment of phase-II work is for 100 marks (Mid-Semester evaluation for 50 marks and End-Semester evaluation for 50 marks) and the grading, like other courses, will be relative.

Correlation between COs and POs

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	3	3	2	2
CO 2	3	3	3	2	2	2
CO 3	3	3	3	2	2	2
CO 4	2	3	2	2	2	3
CO 5	2	3	2	2	2	3
CO 6	2	3	2	2	2	3