Silicon Institute of Technology
| An Autonomous Institute |

Curriculum Structure and Detailed Syllabus

Master of Technology in Computer Science & Engineering

Department of Computer Science & Engineering
Silicon Institute of Technology
Silicon Hills, Patia, Bhubaneswar - 751024

Effective from Academic Year 2022-23
Version: 2.10 (Build: 10-03-2023)

Approval History

ACM#	Date	Resolutions
AC-8	13/08/2022	The curriculum structure and detailed syllabus of 1st and 2nd years as proposed by the Boards of Studies is approved by the Academic Council.

Program Outcomes

Program Outcomes (POs) form a set of individually assessable outcomes that are the components indicative of the post-graduate's potential to acquire competence to practice at the appropriate level. The following POs have been defined for the M.Tech programmes in line with NBA, so that the outcomes can be assessed in a similar manner to UG Engineering programmes:

PO1. Develop an understanding of the theoretical foundations and the limits of computing.

PO2. Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.

PO3. Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.

PO4. Develop understanding and insight of advanced computing techniques and use of advanced tools.

PO5. Explore ideas and undertake original research at the cutting edge of computer science and its related areas.

PO6. Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.

PO7. Understand the impact of IT related solutions in an economic, social and environment context.

PO8. Understand intellectual property rights and overall professional & ethical responsibility.

PO9. Communicate effectively in a technically sound manner with a wide range of audience.

PO10. Continue to learn independently and engage in life-long learning.

Program Educational Objectives (PEOs)

PEO1. Exhibit analytical & problem solving skills to develop efficient algorithms and effective computational systems & solutions under realistic constraints for betterment of society, mankind, and environment.

PEO2. Adapt to technological advancements and acquire skills to engage in professional practice in industry or academics, individually or in a well coordinated team with high levels of integrity and ethics.

PEO3. Conduct independent research in specialized domains of Computer Science & Engineering and pursue higher studies for advancement of computer science and life-long learning.

Program Specific Outcomes (PSOs)

PSO1. Analyze, solve, and create algorithms for computational problems and write efficient programs.

PSO2. Apply principles & practices of Computer Science to develop software solutions to real life problems.

PSO3. Engage as a computer science engineering specialist in industry, higher studies, research & development, academics, or as an entrepreneur.

Course Types & Definitions

L	Lecture
T	Tutorial
P	Practical / Sessional / Laboratory
WCH	Weekly Contact Hours
BS	Basic Sciences
PC	Professional Core
PE	Professional Elective
MC	Mandatory Course
OO	MOOC (Massive Open Online Course)
PJ	Summer Internship / Project Work

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Part I

1st Year M.Tech. (CSE)

Curriculum Structure

Semester I									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	MTCS-T-PC-001	Mathematics for Computer Science	3	1	0	3	1	0
PC	MTCS-T-PC-002	Advanced Data Structures & Algorithms	3	1	0	3	1	0
PC	MTCS-T-PC-003	Advanced Computer Networks	3	0	0	3	0	0
PC	MTCS-T-PC-004	Advanced Computer Architecture	3	0	0	3	0	0
PE		Professional Elective - I	3	0	0	3	0	0
MC	MTBS-T-MC-005	Research Methodology & IPR	2	0	0	0	0	0
PRACTICAL									
PC	MTCS-P-PC-002	Advanced Data Structures & Algorithms Lab	0	0	2	0	0	1
PC	MTCS-P-PC-006	Internet Technologies Lab	0	0	4	0	0	2
		SUB-TOTAL	**17**	**2**	**6**	**15**	**2**	**3**
		TOTAL	**25**			**20**		

Semester II									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PC	MTCS-T-PC-007	Machine Learning	3	0	0	3	0	0
PC	MTCS-T-PC-008	Software Engineering & UML	3	0	0	3	0	0
PC	MTCS-T-PC-009	Scalable Database Systems	3	0	0	3	0	0
PE		Professional Elective - II	3	0	0	3	0	0
PE		Professional Elective - III	3	0	0	3	0	0
MC	MTBS-T-MC-009	English for Research Paper Writing	2	0	0	0	0	0
PRACTICAL									
PC	MTCS-P-PC-007	Machine Learning Lab	0	0	2	0	0	1
PC	MTCS-P-PC-009	Scalable Database Systems Lab	0	0	4	0	0	2
		SUB-TOTAL	**17**	**0**	**6**	**15**	**0**	**3**
		TOTAL	**23**			**18**		

Note: *Courses offered under each elective are given in "List of Electives" on Page 3.*

List of Electives

Code	Elective # and Subjects
Professional Elective - I	
MTCS-T-PE-001	Inferential Statistics
MTCS-T-PE-002	Data Mining & Exploration
MTCS-T-PE-003	Programming & Logic Building
Professional Elective - II	
MTCS-T-PE-004	Soft Computing
MTCS-T-PE-005	Mobile Computing
MTCS-T-PE-006	Advanced Operating Systems
Professional Elective - III	
MTCS-T-PE-007	Artificial Intelligence
MTCS-T-PE-008	Internet of Things
MTCS-T-PE-009	Embedded Systems

Type	Code	Mathematics for Computer Science	L-T-P	Credits	Marks
PC	MTCS-T-PC-001		3-1-0	4	100

Objectives	The objective of this course is to impart knowledge to the students in Linear Algebra, Probability theory and Graph theory to build the necessary mathematical foundation required for other Computer Science subjects.
Pre-Requisites	Knowledge of set theory and matrix algebra is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	System of linear equations, Vector Spaces, subspaces, Linear independence, Basis, Dimension, Four fundamental subspaces of a matrix, Linear transformation, Perpendicular vectors and orthogonal subspaces, Inner product and projection, Least square approximation, Orthogonal basis and Gram-Schmidt process.	**12 Hours**
Module-2	Eigen vectors and Eigen values, Diagonalization of a matrix, Complex matrices, Hermitian, Skew Hermitian and Unitary matrices, Positive definite, Negative definite and semidefinite matrices, Singular value decomposition and Pseudo inverse of a matrix.	**11 Hours**
Module-3	Basics of Graphs, Matrices and isomorphism, Paths, Cycles and connection in graphs, Bipartite graphs, Vertex degree, Euler and Hamiltonian circuits, Trees, Distance in trees and graphs.	**14 Hours**
Module-4	Spanning trees, Enumeration and minimum spanning tree, Matching, Maximum matching, Min-Max theorems, Independent sets and covers, Maximum bipartite matching.	**10 Hours**
Module-5	Cuts and connectivity, Maximum flow, Planarity and coloring.	**9 Hours**
	Total	**56 Hours**

Text Books:

T1. G. Strang, ***Linear Algebra and Applications***, 4th Edition, Wellesley Cambridge Press, 2005.
T2. D. B.West, ***Introduction to Graph Theory***, 2nd Edition, Pearson Education, 2001.

Reference Books:

R1. B. N. Datta, ***Numerical Linear Algebra and Applications***, 2nd Edition, PHI Learning, 2010.
R2. J. W. Demmel, ***Applied Numerical Linear Algebra***, University Press, 2017.
R3. G. Chartrand and P. Zahang, ***Introduction to Graph Theory***, McGraw Hill Education, 2017.

Online Resources:

1. https://nptel.ac.in/courses/111/107/111107106/: by Prof. P. N. Agrawal, IIT Roorkee
2. https://nptel.ac.in/courses/111104137/: by Prof. A. K. Lal, IIT Kanpur
3. https://nptel.ac.in/courses/111106102/: by Prof. S. Maity, IISER PUNE

4. https://www.khanacademy.org/math/linear-algebra
5. http://discrete.openmathbooks.org/dmoi2/ch_graphtheory.html

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand projection in a linear space and apply the concepts to different approximation problems.
CO2	Obtain the singular value decomposition of a matrix and apply the same to obtain the minimum length solution.
CO3	Apply the basic concepts of graphs in modeling real life problems.
CO4	Apply the concept of Matching and Cover in graphs needed for optimization problems.
CO5	Optimize network flow using graph theory models.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1		1					1	1	1	1
CO2	3	3	2		2					2	1	2	1
CO3	2	2	2		1					1	2	2	2
CO4	3	3	3		2					2	2	2	2
CO5	3	3	3		2					2	2	1	2

Type	Code	Advanced Data Structures & Algorithms	L-T-P	Credits	Marks
PC	MTCS-T-PC-002		3-1-0	4	100

Objectives	The objective of this course is to study the advanced methods of designing and analyzing algorithms, understand different classes of problems and their computational complexities, choose appropriate algorithm for solving a specific problem, and recent developments in the area of algorithmic design.
Pre-Requisites	Knowledge of discrete mathematics and problem solving skills is required, and UG level course in data structures and algorithms is preferable.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Algorithm, Asymptotic notations, Recurrences, Solution of recurrences by iterative, Recursion tree, Substitution and Master method; Introduction to data structures, Classification of data structures, Arrays: introduction, Representation of arrays (row and column major), Basic operations on arrays (traverse, insert, delete, search); Stack: Stack model, Representation using array, Basic operations and applications.	**10 Hours**
Module-2	Queue: Queue model, Representation using array, Basic operations, Circular queue; Linked List: Introduction, Types of linked list, Representation in memory, Operations on linked list (traverse, search, insert, delete), Representation of polynomial and its operations (addition, multiplication), Implementation of stack and queue using linked list; Introduction to binary tree, Binary search tree, AVL tree.	**11 Hours**
Module-3	Algorithm design techniques, Divide and conquer strategy for designing algorithms; Sorting: Insertion sort, Merge sort, Heap sort, Quick sort, Randomized quick sort and their correctness proof, Lower bound of comparison sorting, Implementation of priority queue using heap.	**11 Hours**
Module-4	Dynamic Programming, Elements of dynamic programming, Matrix chain multiplication, Longest common sub-sequence, String matching algorithms (Naive, Rabin-Karp,) Greedy algorithms, Elements of greedy strategy, Activity selection problem, Fractional Knapsack problem with correctness proof, Huffman codes; Data structures for disjoint sets, Disjoint set operations, Linked list representation, Path compression, Disjoint set forest.	**12 Hours**
Module-5	Graph algorithms and their characteristics, Breadth-first search and Depth-first search, Minimum spanning trees, Kruskal and Prim's algorithms, Single source shortest path algorithms (Dijkstra), All-pair shortest path algorithm (Floyd-Warshall); NP-Completeness: Proof of NP-hardness and NP-completeness; Approximation Algorithms: Introduction, Vertex cover, Traveling Salesman Problem, Randomized algorithms.	**12 Hours**
	Total	**56 Hours**

Text Books:

T1. M. A. Weiss, ***Data Structures and Algorithm Analysis in C++***, 3rd Edition, Pearson, 2007.
T2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, 3rd Edition, PHI Learning, 2017.

Reference Books:

R1. A. Aho, J. Hopcroft, and J. Ullman, ***The Design and Analysis of Computer Algorithms***, 1st Edition, Addison-Wesley, 1976.
R2. E. Horowitz, S. Sahni, and S. Anderson-Freed, ***Fundamentals of Data Structures in C***, 2nd Edition, Universities Press, 2008.
R3. A. Tenenbaum, ***Data Structures Using C***, 3rd Edition, Pearson Education, 2007.

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102064/: by Prof. N. Garg, IIT Delhi
2. https://nptel.ac.in/courses/106/105/106105085/: by Dr. P. P. Chakraborty, IIT Kharagpur
3. https://nptel.ac.in/courses/106/106/106106131/: by Prof. M. Mukund, IIT Madras
4. http://www.nptelvideos.in/2012/11/design-analysis-of-algorithms.html: Explanation of NP complete and approximation algorithm

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Design algorithms, analyze their time complexities, and understand divide & conquer strategy for sorting problems.
CO2	Apply the basic operations of stack, queue and linked list to solve real world problems.
CO3	Compare various comparison based sorting algorithms and understand their advantages and limitations.
CO4	Develop solutions for a given optimization problem using dynamic programming and greedy algorithm.
CO5	Represent data using graphs to solve various real life problems and understand and Analyze NP-Complete problems and develop approximation algorithm for many real life problem.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	2	1					1	2	2	3
CO2	3	3	1	2	2					1	2	2	2
CO3	3	3	1	2	1					1	2	2	2
CO4	3	3	1	2	1					2	1	2	3
CO5	3	2	1	2	1					1	1	2	2

Type	Code	Advanced Computer Networks	L-T-P	Credits	Marks
PC	MTCS-T-PC-003		3-0-0	3	100

Objectives	The objectives of this course are to study the core concepts of computer networks, network protocols, flow and control of data in networked systems. The course is designed to help students for conducting research in network protocols and network traffic management.
Pre-Requisites	Basic understanding of computer networks and Internet concepts is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world examples and problem statements.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Internet Design & Architecture: Overview of network building blocks, network architecture, OSI reference model, TCP/IP layers and protocols. Network software, Performance; Internet Protocol: IPV4 & IPV6 addresses, Subnets, Internetworking, IPV4 & IPV6 datagram format; ARP, ICMP, DHCP.	**10 Hours**
Module-2	IP Routing: Intra-domain (OSPF/RIP) and Inter domain (BGP) routing, Implementation and Performance of Routers, Multicast Routing, Multiprotocol Label Switching (MPLS) Routing; Transport Layer: Process to Process Delivery, User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) segments, TCP and UDP flow control.	**10 Hours**
Module-3	Congestion Control and Resource Allocation: Issues in resource allocation, Queueing principles, TCP congestion control, QoS; Multimedia: Audio/Video digitization, Streaming Audio Video, Real Time Transport Protocol, Real Time Transport Control Protocol.	**10 Hours**
Module-4	Software Defined Network: SDN Controllers, Network Programmability, Network Function Virtualization, SDN Frameworks; Delay Tolerant Networks: Architecture, DTN Routing Protocols (DSR, AODV), DTN Applications.	**6 Hours**
Module-5	Applications: Traditional applications (SMTP, HTTP, FTP, Telnet), Infrastructure services (DNS, SNMP); Overlay Networks: Overlay Network Applications & Protocols: Routing Overlays, P2P Networks, Content Distribution Networks (CDNs).	**6 Hours**
	Total	**42 Hours**

Text Books:

T1. B. A. Forouzan, ***TCP/IP Protocol Suite***, 3rd Edition, Tata-McGraw-Hill, 2008.
T2. L. L. Peterson and B. S. Davie, ***Computer Networks: A System Approach***, 5th Edition, Elsevier, 2011.

P.T.O

Reference Books:

R1. J. F. Kurose and K. W. Ross, ***Computer Networking***, 3rd Edition, Pearson Education, 2009.
R2. W. Stallings, ***Data and Computer Communications***, 10th Edition, Pearson Education, 2013.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105183/: by Prof. S. Chakraborty and Prof. S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106/106/106106091/:by Prof. H. A. Murthy, IIT Madras
3. https://nptel.ac.in/courses/106/105/106105080/:by Prof. A. Pal, IIT Kharagpur
4. https://www.sciencedirect.com/topics/engineering/delay-tolerant-networks: Advances in Delay-Tolerant Networks (DTNs), 2015
5. https://ieeexplore.ieee.org/document/6994333: Software-Defined Networking - A Comprehensive Survey

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the design of Internet, its drawbacks and how future designs address them.
CO2	Describe the network traffic routing and process delivery mechanisms used in today's Internet.
CO3	Explain network traffic management mechanisms, solutions and their limitations.
CO4	Comprehend SDN enabled networks and data transfers under delay and disruption.
CO5	Visualize infrastructure services on the Internet, overlay architectures, and their applications.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	2			2				1	1	1
CO2	3	3	2	2			2				3	3	2
CO3	3	3	3	2	1		1	1	1		2	3	2
CO4	3	2	2	2	2	1	1	1	1		1	2	2
CO5	1	1	1			1			2	2	2	2	2

Type	Code	Advanced Computer Architecture	L-T-P	Credits	Marks
PC	MTCS-T-PC-004		3-0-0	3	100

Objectives	The objectives of this course are to study the contemporary computer architecture, advanced hardware-based techniques for exploiting instruction level parallelism, implementation techniques for designing high performance memory and storage systems, and techniques used for building high performance scalable multiprocessor systems.
Pre-Requisites	Basic knowledge of computer organization and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving, examples, and recent advancements.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Review of basic computer organization and architecture, Functional units of computer, Instruction format, Instruction set Architecture(ISA), RISC Vs CISC, Addressing modes, Trends in Technology; Measuring, Reporting, and Summarizing performance.	**10 Hours**
Module-2	Quantitative Principles of Computer Design, Amdahl's Law, Instruction Set, Pipelining: Basic concepts, Instructions and arithmetic pipeline, Data hazards, Control hazards and structural hazards, Techniques for handling hazards, Exception handling, Super-scalar, Super-pipelined and VLIW processor architectures.	**8 Hours**
Module-3	Instruction-level parallelism using software approaches: Loop Unrolling, Dynamic instruction scheduling, Scoreboard and Tomasulo Approaches, Speculative execution, Branch prediction techniques, Branch Target Buffer, Review of modern processors, Pentium Processor: IA 32 and P6 micro architectures, ARM Processor.	**8 Hours**
Module-4	Hierarchical Memory Technology: Data and Instruction caches, multi-level caches, Cache memory mapping policies, Cache Coherence, Cache Performance, techniques for reducing cache misses, Virtual memory, Page replacement techniques, Secondary memory technology, RAID.	**8 Hours**
Module-5	Multiprocessor architecture: Taxonomy of parallel architectures; Centralized shared-memory architecture: Synchronization, Memory consistency, interconnections networks, Multi-Processor Vs Multi-Computer, Distributed shared-memory architecture, cluster computers. Data Flow Computer Architecture: Static Data flow computer, Dynamic Data flow computer.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. L. Hennessy and D. A. Patterson, ***Computer Architecture: A Quantitative Approach***, 5th Edition, Morgan Kaufmann, 2012.

T2. D. A. Patterson and J. L. Hennessy, ***Computer Organization & Design: The Hardware/Software Interface***, 5th Edition, Morgan Kaufmann, 2014.
T3. K. Hwang, ***Advanced Computer Architecture: Parallelism, Scalability, Programmability***, McGraw-Hill Education, 2016.

Reference Books:

R1. K. Hwang and F. A. Briggs, ***Computer Architecture and Parallel Processing***, McGraw-Hill, 2017.
R2. B. Parhami, ***Computer Architecture***, Oxford University Press, 2012.

Online Resources:

1. http://www.eecs.berkeley.edu/~pattrsn
2. http://www-inst.eecs.berkeley.edu/~cs252
3. http://www.cs.berkeley.edu/~culler/courses/cs252-s05/
4. https://nptel.ac.in/courses/106102229
5. https://onlinecourses.nptel.ac.in/noc22_cs10/preview

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore computer architectures and parameters to measure performance of a system.
CO2	Explain pipelining, influence of hazards on performance, and apply the principles to design super scalar and super pipelining architectures.
CO3	Describe advanced techniques for instruction level parallelism in modern processors.
CO4	Analyze storage & memory hierarchy, multilevel cache design and optimization techniques.
CO5	Compare different multiprocessor architectures and their interconnection networks.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1				2	2	1	2
CO2	3	3	2	3	2	1				2	2	2	2
CO3	3	3	2	3	2	1				2	2	2	1
CO4	3	3	3	2	2	1				2	2	2	3
CO5	3	3	3	2	2	1				1	2	2	3

Type	Code	Inferential Statistics	L-T-P	Credits	Marks
PE	MTCS-T-PE-001		3-0-0	3	100

Objectives	The objective this course is exercise statistical thinking in designing data collection, derive insights from visualizing data, obtain supporting evidence for data-based decisions and construct models for predicting future trends from data. Additionally, this course prepares the foundation to recognize the importance of data collection, identify limitations in data collection methods, and determine how they affect the scope of inference.
Pre-Requisites	Basic UG level knowledge of probability and statistics is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	**Axioms of Probability**: Sample space and events, axioms of probability, some simple proposition, sample spaces having equally likely outcomes. **Conditional Probability & Independence**: Conditional probabilities, Bayes' formula, independent events. **Random Variables**: Random variables, discrete random variables, expected value, expectation of function of random variable, variance, Bernoulli and binomial random variables, Poisson random variable, properties of cumulative distribution function.	**8 Hours**
Module-2	**Continuous Random Variables**: Expectation and variance of continuous random variables, uniform random variable, Normal random variables, exponential random variables, distribution of a function of a random variable. **Properties of Expectation**: Expectation of sums of random variables, covariance, variance of sums and correlations, conditional expectation, conditional expectation and prediction, Moment generating function. **Distributions Derived from the Normal Distribution**: χ^2, t, and F distributions, The sample mean and the sample variance.	**8 Hours**
Module-3	**Survey Sampling**: Population parameters, simple random sampling (The expectation and variance of the sample mean, estimation of the population variance, The normal approximation to the sampling distribution of $\bar{X}$), estimation of a ratio. **Estimation of Parameters & Fitting of Probability Distributions**: Fitting the Poisson distribution, parameter estimation, the method of moments, and maximum likelihood (Large sample theory for maximum likelihood estimates, confidence intervals from maximum likelihood estimates), the Bayesian approach to parameter estimation(large sample normal approximation to the posterior, computational aspects).	**9 Hours**

Cont'd...

Module-#	Topics	Hours
Module-4	**Testing Hypotheses & Assessing Goodness of Fit**: The Neyman-Person paradigm (specification of the significance level and the concept of a p-value, The null hypothesis, uniformly most powerful tests), the duality of confidence intervals and hypothesis tests, generalized likelihood ratio test, probability plots, tests for normality; Large scale hypothesis testing and false discovery rates. **Comparing Two Samples**: Comparing two independent sample (methods based on the normal distribution, power, a non-parametric method - the Mann-Whitney test, Bayesian approach), comparing paired samples (methods based on the normal distribution, The signed rank test).	**9 Hours**
Module-5	**The Analysis of Variance**: The one-way layout (normal theory, F test, problem of multiple comparisons, Kruskal Wallis test). **The Analysis of Categorical Data**: Fisher's exact test, the Chi-square test of homogeneity and independence, matched pairs designs, odds ratios.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Ross, ***A First Course in Probability***, 8th Edition, Pearson Education, 2010.
T2. J. A. Rice, ***Mathematical Statistics and Data Analytics***, 3rd Edition, Cengage Learning, 2013.

Reference Books:

R1. L. Wasserman, ***All of Statistics : A Concise Course in Statistical Inference***, Springer, 2004.
R2. B. Efron and T. Hastie, ***Computer Age Statistical Inference : Algorithms, Evidence, and Data Science***, 1st Edition, Cambridge University Press, 2016.

Online Resources:

1. https://nptel.ac.in/courses/111/105/111105043/: By Prof. S. Kumar, IIT Kharagpur
2. https://nptel.ac.in/courses/111/102/111102112/: By Prof. N. Chaterjee, IIT Delhi

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply sampling distributions such as χ^2, t, and F distribution in real life problems.
CO2	Estimation the parameters and fitting of probability distributions.
CO3	Apply methods of tests of hypothesis and goodness of fit.
CO4	Conduct hypothesis tests, make decisions using p-value, and draw appropriate conclusions.
CO5	Analyze categorical data, formulate and use linear regression for the given data sets.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1	1	1					1	2	1	2
CO2	2	1	2	1	1					1	2	1	2
CO3	2	2	2	1	2					2	1	1	2
CO4	3	1	2	1	2					2	1	1	2
CO5	2	1	2	1	2					2	1	2	3

Type	Code	Data Mining & Exploration	L-T-P	Credits	Marks
PE	MTCS-T-PE-002		3-0-0	3	100

Objectives	The objective of this course is to study the fundamentals of data mining, understand the need for analysis of large, complex, and information-rich data sets, analyse & use various data mining algorithms, and explore different graphical methods for data exploration.
Pre-Requisites	Knowledge of probability & statistics and algorithms is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Data Mining Basics: Introduction, Application areas in data mining, KDD process; Getting to Know Your Data: Data objects and attributes types; Data Pre-processing: Why pre-process data? Data cleaning, Data integration, Data transformation and reduction.	**8 Hours**
Module-2	Graphical Methods for Data Mining & Exploration: Histograms, Boxplots, Quantile plots, Bagplots, Glyph plots, Scatterplots, Dynamic graphics, Coplots, Dot charts, Plotting points as curves, Biplots.	**8 Hours**
Module-3	Mining Frequent Patterns: Introduction to Associations & Correlations, Market-basket analysis, Frequent item-set generation using Apriori algorithm, Rule generation; Alternative methods for Generating frequent item sets using FP-Growth algorithm, Evaluation of association patterns; From association analysis to correlation analysis.	**8 Hours**
Module-4	Classification: Introduction, Naïve Bayes Classifier, Decision Tree Induction, Nearest Neighbor Classifier; Classification model evaluation techniques, Techniques to improve classification accuracy: Bagging, Boosting, Handling the class imbalance problem.	**10 Hours**
Module-5	Clustering: Overview, K-Means, K Medoid, Agglomerative Hierarchical Clustering, DBSCAN, Cluster Evaluation, Density-based Clustering, Graph-based Clustering, Scalable Clustering Algorithms; Visualizing Clusters: Dendogram, Treemaps, Rectangle Plots, Data image.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Han, M. Kamber, and J. Pei, ***Data Mining Concepts and Techniques***, 3rd Edition, Elsevier, 2011.
T2. W. L. Martinez, A. R. Martinez, and J. L. Solka, ***Exploratory Data Analyis with Matlab***, 2nd Edition, CRC Press (Taylor & Francis Group), 2010.

Reference Books:

R1. C. Bishop, ***Pattern Recognition and Machine Learning***, 1st Edition, Springer, 2007.
R2. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, Springer 2013.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105174/: By Prof. P. Mitra, IIT Kharagpur
2. http://infolab.stanford.edu/~ullman/mining/2003.html: Lecture Notes and Resources by Prof. J. D. Ullman, Stanford University.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the basic concepts & techniques of data mining.
CO2	Explore the different graphical methods of data mining & exploration.
CO3	Generate frequent patterns, derive association rules, and perform correlation analysis.
CO4	Analyze and apply different classification algorithms on real-life data.
CO5	Analyze and apply different clustering algorithms on real-life data.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	1	1						1	1	2	2	3
CO2	3	3	2	2					2	2	2	2	2
CO3	3	3	2	2	2		2		2	2	2	2	3
CO4	3	3	3	2	2		2		2	2	2	3	3
CO5	3	3	3	2	2		2		2	2	2	3	3

Type	Code	Programming & Logic Building	L-T-P	Credits	Marks
PE	MTCS-T-PE-003		3-0-0	3	100

Objectives	The objective of this course is to learn different methodologies such as logic, conditioning, looping, factorization, use of matrices in real-life, object oriented concepts and related problems, puzzles, queuing and hashing and their mapping to coding so as to solve real-life problems.
Pre-Requisites	Knowledge of elementary arithmetic, number system and reasoning is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Logic: Propositional Logic, Logical and Algebraic Concepts, Identities and Normal Forms, Tautology, Predicate logic, Substitutions, First Order Logic.	**8 Hours**
Module-2	Conditionals and Loops-Harmonic Numbers, Newton's method, Number Conversion, Gambler's ruin, Factoring integers, Random walk, Sampling without replacement, Coupon collector, designing filter.	**8 Hours**
Module-3	Random Web Surfer: Transition matrix, Markov chain; Functions: Gaussian functions, Data analysis, Bernoulli trial; Recursion: Euclid's algorithm, Towers of Hanoi, Gray code, Recursive graph, Brownian bridge.	**9 Hours**
Module-4	OOP: Image processing, Screen scrapping, Splitting file, Counter system, Spatial vectors, Similarity detection, Body simulation.	**8 Hours**
Module-5	Problem Solving Strategies: Puzzles, Sudoku, Searching & Sorting, Stack and Queue, M/M/1 queue, Load Balancing, Hashing, Shortest path algorithms.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Sedgewick, K. Wayne, and R. Dondero, ***Introduction to Programming in Python: An Interdisciplinary Approach***, 1st Edition, Pearson Education, 2016.
T2. D. Zingaro, ***Learn to Code by Solving Problems: A Python Programming Primer***, 1st Edition, No Starch Press, 2021.

Reference Books:

R1. V. A. Spraul, ***Think Like a Programmer: An Introduction to Creative Problem Solving***, No Starch Press, 2012.
R2. J. D. Bransford and B. S. Stein, ***The Ideal Problem Solver***, 2nd Edition, W. H. Freeman Company, 1993.

Online Resources:

1. https://nptel.ac.in/courses/106102013: Logic for CS by Prof. S. A. Kumar, IIT Delhi

P.T.O

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Develop logical thinking through different logical analysis, truth table, and correctness proofs.
CO2	Investigate significance of number theory in computational processes and analyze different series for prediction purposes.
CO3	Map real-life problems to mathematical models such as graph theoretic methods, and other functions to solve them problems by computer programming.
CO4	Design and develop Object-Oriented models through abstraction and apply them with the principle of inheritance, polymorphism and encapsulation for simulation.
CO5	Build different processing environments using the concepts of stacks, queues and prepare public ledger using hashing technique.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3	2	2					1	3	2	1
CO2	2	2	2	1	1					1	1	2	1
CO3	3	3	2	2	2					2	2	2	2
CO4	2	3	3	2	2					2	2	3	3
CO5	2	3	3	3	3					2	2	3	3

Type	Code	Research Methodology & IPR	L-T-P	Credits	Marks
MC	MTBS-T-MC-005		2-0-0	0	100

Objectives	The objective of this course is to introduce the principles and practices involved in conducting scientific research. The course is designed to cover three broad areas - The Scientific Method and Hypothesis Testing, Review of Literature and writing Technical Reports, and the elements of Intellectual Property Rights (IPR).
Pre-Requisites	Basic knowledge of probability & statistics will be helpful.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving & examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to research, its significance and meaning; Types of research - fundamental, pure, theoretical, applied and experimental; Identification of the research problem and formulation of hypothesis; Research design and errors in research, error analysis; The Scientific Method as the established way of doing research; Data collection, measurement and scaling techniques.	**8 Hours**
Module-2	Meaning and need for hypothesis, Types of hypothesis, Functions and characteristics of a good hypothesis; Statistical testing of hypothesis – T-test, Chi-squared test; Sampling methods, Types of sampling, Probability and non-probability sampling; One-sample and two-sample tests, Correlation and regression analysis.	**8 Hours**
Module-3	Literature - types and review; Literature survey using the web, Search engines; Journal, report and thesis writing; Types of reports, Structure of the research report and presentation of results.	**7 Hours**
Module-4	Code of ethics in research - Intellectual Property Rights; Details of patents, Copyrights, Trademarks and Trade Secrets.	**5 Hours**
	Total	**28 Hours**

Text Books:

T1. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2004.
T2. D. Chawla & N.Sodhi, ***Research Methodology: Concepts and Cases***, 2nd Edition, Vikas Publishing, 2016.

Reference Books:

R1. E. L. Lehman & J. P. Romano, ***Testing Statistical Hypothesis***, 3rd Edition, Springer, 2008.
R2. R. Panneerselvam, ***Research Methodology***, 2nd Edition, Prentice Hall India, 2013.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/127106227: by Prof. S. Banerjee, IIT Madras
2. https://nptel.ac.in/courses/109105115: by Prof. A. Malik, IIT Kharagpur
3. https://nptel.ac.in/courses/109105112: by Prof. T. K. Bandyopadhyay, IIT Kharagpur
4. https://ocw.mit.edu/courses/sloan-school-of-management/15-347-doctoral-seminar-in-research-methods-i-fall-2004/readings/: MIT Open Courseware (MIT-OCW).

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Disseminate the scientific method as a structured way of conducing scientific research.
CO2	Apply statistical principles for conducting hypothesis testing.
CO3	Conduct effective review of literature and write technical reports.
CO4	Acquire knowledge of the various intellectual property rights.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1	1	1					1	1	1	2
CO2	2	2	1	1	1					1		1	1
CO3					3				2	1		1	2
CO4								3		1		1	2

Type	Code	Advanced Data Structures & Algorithms Lab	L-T-P	Credits	Marks
PC	MTCS-P-PC-002		0-0-2	1	100

Objectives	The objective of this laboratory course is to provide practical exposure on how to use various data structures efficiently, with emphasis on design & implementation of efficient algorithms for specific real world applications.
Pre-Requisites	Knowledge of programming and topics taught in the theory class is required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Implementation of Linear Search and Binary search.
2	Implementation of stack using array.
3	Implementation of queue.
4	Operations of queue and circular queue using array.
5	Single linked list operations
6	Double linked list operations.
7	Implementation of merge sort.
8	Implementation of heap and heap sort.
9	Implementation of quick sort.
10	Implementation of Binary Search Tree.
11	Longest Common Sub-sequence.
12	Graph Traversal using BFS and DFS.
13	Kruskal's Algorithm for Minimum Spanning Tree.
14	Dijkstra's Single source shortest path algorithm.

Text Books:

T1. M. A. Weiss, ***Data Structures and Algorithm Analysis in C***, 2nd Edition, Pearson, 2002.
T2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, ***Introduction to Algorithms***, 3rd Edition, PHI Learning, 2017.

Reference Books:

R1. M. T. Goodrich and R. Tamassia, ***Algorithm Design: Foundations, Analysis and Internet Examples***, John Wiley & Sons, 2006.

Online Resources:

1. https://nptel.ac.in/courses/106/102/106102064/: by Prof. N. Garg, IIT Delhi
2. https://nptel.ac.in/courses/106/105/106105085/: by Dr. P. P. Chakraborty, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Implement various operations on arrays and stack.
CO2	Design functions to implement basic operations on queue, and linked list.
CO3	Apply dynamic programming and greedy paradigms to solve real life problems.
CO4	Explain and implement various tree data structures and search on them.
CO5	Formulate engineering problems and solve them using graph algorithms.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	1	1					1	2	2	3
CO2	3	3	2	1	1					1	2	2	2
CO3	3	3	2	2	2					1	2	2	2
CO4	3	3	3	2	2					1	1	2	3
CO5	3	3	3	2	2					1	1	2	2

Type	Code	Internet Technologies Lab	L-T-P	Credits	Marks
PC	MTCS-P-PC-006		0-0-4	2	100

Objectives	The objective of this course is to provide hands-on exposure on development of static & dynamic web pages using client-side and server-side programming with database connectivity and deployment of web applications.
Pre-Requisites	Knowledge on programming, databases, internet and browsers is required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	HTML - HTML5 Tags, text, heading, images, lists.
2	HTML - Table, Form design and use of GET and POST method.
3	HTML - ifrmae, Embedding audio and video, image map, anchor tag.
4	CSS - Introduction to CSS3, types of CSS, CSS selectors.
5	CSS - Box model, CSS Grid, Flex box.
6	JS - Introduction to client side scripting, Evolution of JS, Document Object Model (DOM), Comments, Variables.
7	JS - String, Array and Function.
8, 9	JS - Event Handling, Client side validation, Object, Class.
10, 11	jQuery - Introduction to jQuery, DOM Manipulation, Event Handling, Animation.
12	Server Side Scripting - Architecture of web application, Apache HTTP Server, Introduction to PHP - Tags, Comment line, Variable and Print statement.
13	PHP - Flow control and Loops.
14	PHP - Strings and Regular Expression.
15	PHP - Array and Functions.
16	Object Oriented PHP - Class, Object, Inheritance.
17	PHP - Form handling and Validation.
18	MySQL - Features, Data Types, DDL, DML and DQL, MySQL Functions.
19, 20	Connecting PHP with MySQL, CURD Operation.
21	AJAX - Use of GET and POST method to handle sever side data.
22	Project Assignment (requirements, test scenarios & implementation criteria).
23-27	Development of assigned project using various web technologies taught.
28	Demonstration of working project, presentation, viva and evaluation.

Text Books:

T1. T. A. Powell, ***The Complete Reference HTML and CSS***, 5th Edition, McGraw-Hill, 2017.

T2. R. Nixon, ***Learning PHP, MySQL & JavaScript with jQuery, CSS & HTML5***, 4th Edition, O'Reilly Media, 2014.

Reference Books:

R1. A. Forbes, ***The Joy of PHP: A Beginner's Guide to Programming Interactive Web Applications with PHP and MySQL***, 3rd Edition, Create Space Independent Publishing, 2015.
R2. T. Butler and K. Yank, ***PHP & MySQL: Novice to Ninja***, 7th Edition, Site Point, 2022.

Online Resources:

1. https://onlinecourses.swayam2.ac.in/aic20_sp32/preview: by Prof K. Moudgalya, IIT Bombay
2. https://nptel.ac.in/courses/106/105/106105084/: Prof. I. Sengupta, IIT Kharagpur
3. https://developer.mozilla.org/en-US/docs/Learn/JavaScript: JavaScript documentation
4. https://learn.jquery.com/: jQuery and AJAX documentation
5. https://www.php.net/manual/en/: PHP Reference Manual
6. https://dev.mysql.com/doc/refman/8.0/en/: MySQL Reference Manual

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Create well designed web pages using valid HTML and CSS.
CO2	Develop rich interactive web pages using JavaScript and jQuery.
CO3	Perform asynchronous communication with web server using AJAX.
CO4	Develop dynamic websites using server-side scripts and backend database.
CO5	Create dynamic interactive web applications using various tools and languages.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1	2						2	1	2	2
CO2	3	2	1	3						2	1	2	2
CO3	3	2	1	3						2	1	1	2
CO4	2	3	3	3						3	2	2	3
CO5	2	3	3	3						3	2	2	3

Type	Code	Machine Learning	L-T-P	Credits	Marks
PC	MTCS-T-PC-007		3-0-0	3	100

Objectives	The objective of this course is to learn patterns and concepts from data using various machine learning techniques focusing on recent advances. Students will explore supervised and unsupervised learning paradigms, deep learning technique and various feature extraction strategies.
Pre-Requisites	Knowledge of algorithms, optimization, and matrix theory is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required. Sessions shall be interactive with focus on problem solving and real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Subset selection , Ridge regression, Least angle regression and Lasso, Linear Discriminant Analysis, Logistic regression, Generative models for discrete data (Bayesian concept learning, Naïve Bayes classifier).	**10 Hours**
Module-2	Dimensionality reduction: Factor analysis, Principal Components, Kernel PCA, Independent Component analysis, ISOMAP, LLE, Feature Selection, Spectral Clustering.	**7 Hours**
Module-3	Model Assessment and Selection : Bias, Variance, and model complexity, Bias-variance trade off, Optimization of the training error rate, Estimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross-validation, Bootstrap methods, Conditional or expected test error.	**8 Hours**
Module-4	Additive Models, Trees, and Boosting: Generalized additive models, Regression and classification trees, Boosting methods-exponential loss and AdaBoost, Random forests and analysis, Numerical Optimization via gradient boosting, Examples (Spam data, California housing, New Zealand fish, Demographic data).	**8 Hours**
Module-5	Support Vector Machines(SVM), K-nearest Neighbor and Cluster Analysis: Basis expansion and regularization, Kernel smoothing methods, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest Neighbor classifiers (Image Scene Classification), Cluster analysis, Gaussian mixtures and selection.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. T. Hastie, R. Tibshirani, J. Friedman, ***The Elements of Statistical Learning: Data Mining, Inference and Prediction***, 2nd Edition, Springer Verlag, 2009.
T2. K. P. Murphy, ***Machine Learning: A Probabilistic Perspective***, 4th Edition, MIT Press, 2012.

Reference Books:

R1. C. Bishop, ***Pattern Recognition and Machine Learning***, Springer, 2007.
R2. T. Mitchel, ***Machine Learning***, McGraw-Hill Science, 1997.
R3. G. James, D. Witten, T. Hastie, and R. Tibshirani, ***An Introduction to Statistical Learning with Applications in R***, Springer, 2013.
R4. L. Wasserman, ***All of Statistics***, 1st Edition, Springer, 2004.

Online Resources:

1. https://nptel.ac.in/courses/111107137: by Prof. S. K. Gupta and Dr. S. Kumar, IIT Roorkee
2. https://nptel.ac.in/courses/106105152: by Prof. S. Sarkar, IIT Kharagpur
3. https://nptel.ac.in/courses/106106139: by Dr. B. Ravindran, IIT Madras
4. https://github.com/josephmisiti/awesome-machine-learning: An exhaustive index of machine learning concepts and programming materials.
5. http://mlss.cc/: Machine Learning Summer School Study Material.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Formulate and solve machine learning problems using linear models of regression and classification.
CO2	Develop understanding of unsupervised learning models of dimensionality reduction and factor analysis.
CO3	Analyze the building blocks of probabilistic model assessment and selection.
CO4	Understand theoretical principles of additive models, trees and boosting with examples.
CO5	Apply the tools in cluster analysis, support vector machines and K-nearest neighbors.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2				1	2	2	3
CO2	3	3	3	1	2	2				1	2	2	2
CO3	3	3	3	3	3	2				1	1	1	2
CO4	3	3	3	3	3	2				2	2	2	3
CO5	3	3	3	3	3	2				3	2	2	3

Type	Code	Software Engineering & UML	L-T-P	Credits	Marks
PC	MTCS-T-PC-008		3-0-0	3	100

Objectives	The objective of this course is to learn the fundamentals of software engineering, software development life cycle & project management, object-oriented software design, development, testing and quality assurance.
Pre-Requisites	Basic programming knowledge and database concepts is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Software Engineering: Evolution and Emergence of Software Engineering; Software Life Cycle Models: Classical Waterfall Model, Iterative Waterfall Model, V Model, Prototyping Model, Incremental Development Model, Evolutionary Model, RAD model, Agile development models & Spiral model.	**8 Hours**
Module-2	Software Project Management: Project Planning, Metrics for Project Size Estimation, Project Estimation Techniques, COCOMO model, Halstead's Software Science, Scheduling, Staffing, Scheduling tools, Risk Management; Requirements Analysis & Specification: Requirements Gathering & Analysis, SRS, Decision Trees & Tables, Formal System Specification.	**9 Hours**
Module-3	Software Design: Overview of the Design Process, Cohesion and Coupling, Layered Arrangement of Modules, Approaches to Software Design; FOD: SA/SD Methodology, DFD, Structured Design and Detailed Design, Design for Client Server Systems.	**9 Hours**
Module-4	Object Modelling Using UML: Object-Orientation Concepts, Unified Modelling Language (UML); UML Models: Use Case Model, Class Diagram, Interaction Diagrams, Activity Diagram, State Chart Diagram, Package, Component and Deployment Diagrams; Object-Oriented Software Development: OOAD Methodology.	**8 Hours**
Module-5	Software Testing: Coding & Code Review, Basic Concepts of Testing, Black-box and White-box Testing, Debugging, Integration Testing, Testing Object-Oriented Programs, Integration Testing, System Testing; Software Reliability, Six Sigma; Software Maintenance, Emerging Trends; Building Blocks for CASE: Taxonomy of CASE Tools, Integrated CASE Environments, Integration Architecture, CASE Repository, Case Study of Tools.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Mall, ***Fundamentals of Software Engineering***, 4th Edition, PHI Learning, 2014.
T2. C. Larman, ***Applying UML and Patterns***, 3rd Edition, Pearson Education, 2015.
T3. R. S. Pressman, ***Software Engineering - A Practitioner's Approach***, 7th Edition, McGraw-Hill, 2010.

Reference Books:

R1. I. Somerville, ***Software Engineering***, 9th Edition, Pearson Education, 2013.
R2. E. Gamma, R. Helm, R. Johnson, and J. Vlissides, ***Design Patterns: Elements of Reusable Object-Oriented Software***, 1st Edition, Pearson Education, 2008.

Online Resources:

1. https://nptel.ac.in/courses/106105182/: by Prof. R. Mall, IIT Kharagpur.
2. https://nptel.ac.in/courses/106101061/: by Prof. N. L. Sharda, IIT Bombay.
3. https://www.tutorialspoint.com/softwareengineering/softwareengineeringtutorial.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe fundamentals of software engineering and life cycle models.
CO2	Conduct requirements analysis, estimation, planning, scheduling, and other software project management activities.
CO3	Create high-level & detail-level design of a software using various design methodologies.
CO4	Visualize object oriented approach for software design using Unified Modeling Language.
CO5	Code, review, test and maintain software products confirming to quality standards.

Program Outcomes Relevant to the Course:

PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1		2	2			2	3		2		1	1	2
CO2		3	3			2	3		2		2	2	3
CO3		3	3			2	3		1		2	2	2
CO4		3	2			2	1		2		2	2	3
CO5		2	1			2	1		2		3	2	3

Type	Code	Scalable Database Systems	L-T-P	Credits	Marks
PC	MTCS-T-PC-009		3-0-0	3	100

Objectives	The objective of the course is to revisit relational databases and study advanced scalable database systems for managing large amounts of structured, semi-structured and complex data for various applications.
Pre-Requisites	Basic knowledge of data structures and algorithms is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required. Sessions shall be interactive with focus on problem solving and real-life examples.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Basic concepts & definitions, Three-schema architecture, Data independence, Data models, Database languages, ER model, Constraints & keys, Relational model, Mapping ER model to relational schema, Relational algebra, Basic operations, Joins operations, Grouping & aggregation, Modification of database.	**8 Hours**
Module-2	Database design, Functional dependencies, Armstrong axioms, Attribute closure, Normalization, Dependency & attribute preservation, Lossless join, Normal forms (1NF, 2NF, 3NF, BCNF), Storage strategies & architecture, File and record organization, Types of indexes, B-Tree, B+ Tree, Index files, Hashing.	**9 Hours**
Module-3	Query processing, Evaluation of relational algebra expressions, Query optimization; Transaction processing, ACID properties, Serializability, Concurrency control - Lock & Timestamp-based protocols, Deadlocks - prevention, detection & recovery, Database recovery, Types of failures, Log-based recovery, Checkpoints.	**9 Hours**
Module-4	Parallel Databases - Introduction, Parallelism in Databases, Distributed database systems, Reference architecture, Fragmentation, Allocation, Replication, Distribution transparency, Distributed database design, Distributed query processing, Distributed transactions, 2-Phase commit protocol, Distributed concurrency control & deadlock handling.	**8 Hours**
Module-5	Concepts of NoSQL, Why NoSQL, Aggregate data models (key-value & document data models, column-family stores), Data modeling details - Relationships, Graph databases, Schemaless databases, Materialized views, Modeling for data access, Distribution Models - single server, shrading, replication, Consistency, Relaxing consistency & durability, Version stamps, Map-Reduce.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Silberschatz, H. F. Korth, and S. Sudarshan, ***Database System Concepts***, 6th Edition, McGraw-Hill Education, 2013.

T2. S. Ceri and G. Pellagatti, ***Distributed Databases: Principles and Systems***, 1st Edition, McGraw-Hill Education, 2017.
T3. P. J. Sadalage and M. Fowler, ***NoSQL Distilled***, 1st Edition, Pearson Education, 2012.

Reference Books:

R1. R. Elmasri and S. B. Navathe, ***Fundamentals of Database Systems***, 7th Edition, Pearson Education, 2016.
R2. R. P. Mahapatra and G. Verma, ***Database Management Systems***, 1st Edition, Khanna Publishing, 2016.
R3. M. T. Özsu and P. Valduriez, ***Principles of Distributed Database Systems***, 2nd Edition, Pearson Education, 2006.
R4. D. Sullivan, ***NoSQL for Mere Mortals***, 1st Edition, Addison Wesley, 2015.

Online Resources:

1. https://nptel.ac.in/courses/106104135/: By Prof. A. Bhattacharya, IIT Kanpur
2. https://nptel.ac.in/courses/106105175/: By Prof. P. P. Das, IIT Kharagpur
3. https://nosql-database.org/: Resources for NoSQL

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain concepts of various data models and write queries using relational algebra.
CO2	Design normalized relational databases and implement appropriate indexing.
CO3	Understand query optimization, transactions, concurrency, and recovery in RDBMS.
CO4	Visualize design & working principles of distributed databases for enterprise applications.
CO5	Explore NoSQL databases for storage, manipulation, and analysis of non-relational data.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2		2	1				1	1	2	2
CO2	3	3	3		2	1				1	2	3	3
CO3	3	3	3		2	1			1	1	3	3	3
CO4	3	3	3		3	2			2	2	2	3	2
CO5	3	3	3		3	2			2	3	2	2	3

Type	Code	Soft Computing	L-T-P	Credits	Marks
PE	MTCS-T-PE-004		3-0-0	3	100

Objectives	The objectives of this course is to introduce the fundamentals of non-traditional computing techniques and approaches to solve hard real-world problems using artificial neural networks, fuzzy systems and nature inspired computing, and derivative based & multi-objective optimization along with different aspects of hybridization with some case studies.
Pre-Requisites	Knowledge of Linear Algebra, algorithm design, and data structures are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Fuzzy Set Theory: fuzzy sets, basic definition and terminology, Set-Theoretic operations, Membership Function Formulation and Parameterization, T-norm, T-conorm; Fuzzy Rules and Fuzzy Reasoning: Extension Principle and Fuzzy Relations, Fuzzy if-then rules, Fuzzy reasoning; Fuzzy Inference Systems: Mamdani Fuzzy models, Sugeno Fuzzy models, Tsukamoto Fuzzy models.	**9 Hours**
Module-2	Derivative based Optimization: Local optima and global optima, constrained optimization, optimality conditions and matrix calculus, Gradient descent and stochastic gradient descent, Newton's method and Quasi-Newton methods (BFGS, L-BFGS), Linear Optimization, Duality, and Convex optimization, Conjugate Gradient.	**8 Hours**
Module-3	Neural Networks: Model of a neuron, LMS, Perceptron, MLP and Back propagation algorithm, heuristics for improving performance of BPA, Higher order convergence methods for BPA (Newton method, conjugradient method, LM, BFGS); Radial Basis Function Networks, Self-Organizing Maps.	**9 Hours**
Module-4	Nature Inspired Computing: Simulated Annealing, Genetic Algorithm, Differential Evolution, Ant & Bee Algorithm, Particle Swarm Optimization, Firefly algorithm, Cuckoo Search, Bat Algorithm, Harmony Search, Flower algorithm.	**8 Hours**
Module-5	Hybrid Methods: Adaptive Neuro-Fuzzy Inference Systems, Neuro genetic Systems, GA Fuzzy systems; Multi-Objective Optimization: Single and multi-objective optimization, Multi-Objective optimization problem, Principles of multi-objective optimization, difference with single-objective optimization, Dominance and pareto-optimality, Optimality conditions.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. J. S. R. Jang, C.-T, Sun, and E. Mizutani, ***Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence***, 1st Edition, Pearson Education, 2015.

T2. S. Boyd and L. Vandenberghe, ***Convex Optimization***, Cambridge University Press, 2004.
T3. S. Haykin, ***Neural Networks: A Comprehensive Foundation***, 2nd Edition, Pearson Education.

Reference Books:

R1. X. -S. Yang, ***Nature-Inspired Optimization Algorithms***, 1st Edition, Elsevier Publication, 2014.
R2. K. Deb, ***Multi-Objective Optimization using Evolutionary Algorithms***, 1st Edition, John Wiley & Sons Ltd, 2001.

Online Resources:

1. https://nptel.ac.in/courses/106105173: by Prof. D. Samanta, IIT Kharagpur
2. https://nptel.ac.in/courses/112103301: by Prof. D. Sharma, IIT Guwahati
3. https://nptel.ac.in/courses/111105039: by Prof. A. Goswami and Dr. D. Chakraborty, IIT Kharagpur
4. http://www.soukalfi.edu.sk/01_NeuroFuzzyApproach.pdf
5. https://web.stanford.edu/~boyd/cvxbook/bv_cvxbook.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Apply fuzzy logic and fuzzy inference to design automation systems for real-life problems.
CO2	Explain the concepts of derivative based optimization and use it to solve problems.
CO3	Apply Artificial Neural Networks (ANN) to solve real-life engineering problems.
CO4	Adopt different nature inspired computing techniques to solve real world problems.
CO5	Develop hybrid models for complex problem solving, identify multi-objective aspects of real-life problems, and apply different techniques to solve them.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	3	2	3					3	2	2	3
CO2	3	3	1	1	1					2	1	2	2
CO3	3	3	3	2	3					2	2	2	3
CO4	3	3	3	2	3					3	2	2	2
CO5	3	3	3	2	3					3	2	3	3

Type	Code	Mobile Computing	L-T-P	Credits	Marks
PE	MTCS-T-PE-005		3-0-0	3	100

Objectives	The objective of this course is to study networking principles & wireless communication on cellular networks, wireless internet, wireless devices & satellite systems for unobtrusive connectivity that is always available.
Pre-Requisites	Basic understanding of computer networks & Internet is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples & problem solving.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Personal Communication Systems (PCS): Wireless Technologies, Signals and Frequency; Cellular Systems: Structure, Cluster, Frequency Reuse and Splitting; Broadcast Systems: Digital Audio and video broadcasting, Convergence of broadcasting and mobile communications. GSM: Channels, Bands, Architecture, Mobility Management, Handover Detection & Management; GPRS: Architecture, Interfaces, and Network Protocols.	**8 Hours**
Module-2	Wireless LAN (WLAN): IEEE 802.11 System Architecture, Ad-Hoc and Infrastructural Mode, MAC Frame Format; Bluetooth: Piconet, Scatternet, Protocol stack, Profile; WAP: Architecture, Components, Gateway and Protocol Stack, WML Script: Variables, Control Structure & Functions; IMT 2000 Standards: WCDMA and CDMA 2000.	**9 Hours**
Module-3	Mobile IP: Overview, Requirements, Entities, Agent Advertisement & Discovery, Registration, IP Packet Delivery, Tunnelling and Encapsulation; IPv6, DHCP, ICMP; Routing in Ad-hoc Network: DSDV, AODV, DSR, ZRP; Mobile Transport Layer: I-TCP, Snooping TCP, M-TCP, T-TCP; WLL: Architecture, Functionalities; Wireless Enterprise Networks.	**8 Hours**
Module-4	Satellite Communication Networks: Architecture, handoffs, Mobile Satellite Systems (GEO, LEO, MEO, HEO), satellite constellation for satellite phone, Case studies: Iridium, GLOBALSTAR, GLONASS, Virtual Private Network: Features, Remote Access, Site to Site VPN, Protocols; Security Challenges in Mobile Computing: Algorithms and Implementation.	**8 Hours**
Module-5	Wireless Application Protocol: Architecture, Protocols. VoIP & Real Time Protocols: Multimedia Content Delivery in Mobile Network, Introduction to Mobile OS: Android, iOS. Introduction to Application Development for Mobile Platforms, Introduction to Android Studio and Java Programming Language, 3-tier Architecture for Mobile Computing, Design Considerations and Computing through Internet, Internet of Things, Future/Current Trends and Research: A Discussion.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. J. Schiller, ***Mobile Communication***, 2nd Edition, Pearson Education, 2008.
T2. Y. -B. Lin and I. Chlamtac, ***Wireless and Mobile Network Architectures***, 1st Edition, John Wiley & Sons, 2008.
T3. D. Griffiths and D. Griffiths, ***Head First Android Development: A Brain-Friendly Guide***, 2nd Edition, O'Reilly Media, 2019.

Reference Books:

R1. V. K. Garg, ***Wireless Communication and Networks***, 2nd Edition, Pearson Education, 2003.
R2. A. K. Talukder, H. Ahmed, and R. Yavagal, ***Mobile Computing***, 2nd Edition, Tata McGraw-Hill, 2010.
R3. U. Hansmann, L. Merk, M. Nicklous, and T. Stober, ***Principles of Mobile Computing***, 2nd Edition, Springer, 2003.

Online Resources:

1. https://nptel.ac.in/courses/106/106/106106147/: by Prof. P. Singh and Prof. S. Iyer, IIT Madras
2. https://nptel.ac.in/courses/117/104/117104099/: by Prof. A. K. Jagannatham, IIT Kanpur
3. https://nptel.ac.in/courses/106/106/106106167/: by Prof. D. K. Pillai, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain frequency bands, communication domains and functionalities of GSM & GPRS.
CO2	Explain the MAC layer protocols, Ad-hoc Networks and different 2G and 3G standards.
CO3	Implement different protocols of transport layer and analyze their performance.
CO4	Comprehend the mechanisms of satellite networks and VPN with cellular networks.
CO5	Utilize appropriate wireless application protocols for enterprise application development.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	1								1	1	2
CO2	3	2	2				1				2	2	2
CO3	2	3	2	3	1		2				2	2	2
CO4	3	2	3	2			3				1	2	3
CO5	3	2	3		2		1			3	2	2	3

Type	Code	Advanced Operating Systems	L-T-P	Credits	Marks
PE	MTCS-T-PE-006		3-0-0	3	100

Objectives	The objectives of this course is to study the basics of modern operating systems and their implementation techniques followed by advanced concepts for developing systems and applications.
Pre-Requisites	Knowledge of computers and basic data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on real-world examples and problem statements.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction, Structures - Simple Batch, Multi Programmed, Time-shared, Personal Computer, Parallel & Distributed Systems, Real-Time Systems, System components, Operating System Services, System Calls; Process concepts and scheduling, Operation on processes, Cooperating Processes, Threads, and Inter-process Communication.	**10 Hours**
Module-2	CPU Scheduling: Scheduling Criteria, Scheduling Algorithm; Memory Management: Logical versus Physical Address Space, Contiguous and non-contiguous memory allocation, Paging, Segmentation.	**8 Hours**
Module-3	Virtual Memory: Demanding Paging, Page Replacement, Page Replacement Algorithm, Allocation of Frames, Thrashing. Deadlocks - System Model, Dead locks Characterization, Methods for Handling Dead locks Deadlock Prevention, Deadlock Avoidance, Deadlock Detection and Recovery.	**8 Hours**
Module-4	Introduction to Distributed systems: Goals of distributed system, hardware and software concepts, Design issues, Lamport's Logical Clocks, Vector Clocks, Causal Ordering of Messages, Global State, Chandy-Lamport's Global State Recording Algorithm.	**8 Hours**
Module-5	Distributed Mutual Exclusion: Ricart-Agrawala Algorithm, Maekawa Algorithm; Distributed Deadlock Handling Strategies: Centralized Deadlock-Detection Algorithms, Distributed Deadlock Detection Algorithms, Hierarchical Deadlock Detection Algorithms.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Silberchatz, P. B. Galvin, and G. Gagne, ***Operating System Principles***, 7th Edition, Wiley, 2006.
T2. M. Singhal and N. G. Sivaratri, ***Advanced Concepts in Operating Systems***, Tata McGraw-Hill, 2017.

Reference Books:

R1. P. K. Sinha, ***Distributed Operating Systems Concepts and Design***, 1st Edition, PHI Learning, 1998.
R2. A. S. Tanenbaum and H. Bos, ***Modern Operating Systems***, 4th Edition, Pearson Education, 2016.
R3. T. K. G. Coulouris and J. Dollimore, ***Distributed Systems: Concepts and Design***, 2nd Edition, Pearson Education, 2010.

Online Resources:

1. https://nptel.ac.in/courses/106102132: by Prof. S. Bansal, IIT Delhi
2. https://nptel.ac.in/courses/106108101: by Prof. P. C. P. Bhatt, IISc Bangalore
3. https://nptel.ac.in/courses/106106168: by Dr. R. Misra, IIT Patna
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-828-operating-system-engineering-fall-2012/lecture-notes-and-readings/
5. https://www.cse.iitb.ac.in/~mythili/os/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the differences between various types of systems, processes and threads.
CO2	Explain the basics of CPU scheduling and memory management in modern operating systems.
CO3	Apply page-replacement algorithms for memory allocation and dealing with deadlocks.
CO4	Explain clock and message synchronization in distributed systems.
CO5	Analyze and differentiate between centralized and distributed deadlock detection.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	3	2		2					1	1	1	1
CO2	3	2	2		1					1	2	2	3
CO3	3	2	2		1					1	2	2	2
CO4	3	3	2		1					1	2	2	2
CO5	3	2	2		3					1	2	2	3

Type	Code	Artificial Intelligence	L-T-P	Credits	Marks
PE	MTCS-T-PE-007		3-0-0	3	100

Objectives	The objective of the course is to study the basics of Artificial Intelligence (AI), problem solving techniques, methods of knowledge representation and applications of AI in various information processing applications.
Pre-Requisites	Knowledge of algorithms and data structures is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Artificial Intelligence: Introduction; Intelligent Agents: Agents and Environment, Nature of Environments, Structure of Agents; Problem Solving: Solving Problems by Searching, Classical problems of searching; Uninformed Search Techniques: DFS, BFS, Depth Limited Search, Iterative Deepening Search, Uniform cost search, Bidirectional search, Comparing Different Techniques.	**8 Hours**
Module-2	Informed Search & Exploration: Informed (Heuristic) search strategies: Greedy Search, A*, AO*, SMA*, Local Search Algorithms & Optimization Problems: Hill Climbing, Stimulated Annealing, Genetic Algorithms; Constraint Satisfaction Problems: Introduction, Backtracking search for CSPs; Adversarial Search: Games, Optimal Decisions in Games, Alpha-Beta Pruning.	**10 Hours**
Module-3	Knowledge & Reasoning: A Knowledge Based Agent, WUMPUS WORLD Environment, Propositional Logic, First Order Predicate Logic; Inference in First-Order Logic: Propositional vs. First-Order Logic, Unification and Lifting, Forward Chaining, Backward Chaining, Resolution; Knowledge Representation: Ontological Engineering, Objects, Semantic Nets, Frames.	**8 Hours**
Module-4	Planning: The Planning Problem, Planning with State-Space Search, Partial-Order Planning, Planning Graphs; Uncertain Knowledge & Reasoning: Acting under Uncertainty, Bayes Rule and its use; Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks. Probabilistic Reasoning over time: Time and Uncertainty, Inference in temporal model, Hidden Markov Model.	**8 Hours**
Module-5	Learning: Learning from Observations, Inductive Learning, Learning Decision Trees, Ensemble Learning; Statistical learning methods: Naïve Bayes models, Instance based learning, Neural Network Perceptron Model; Reinforcement learning; Communication: Lexical Analysis, Syntactic Analysis, Semantic Interpretation, Discourse Understanding; Perception: Introduction, Image Formation; Robotics: Introduction, Hardware, Sensors.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. J. Russell and P. Norvig, ***Artificial Intelligence - A Modern Approach***, 3rd Edition, Pearson Education, 2016.

Reference Books:

R1. E. Rich, K. Knight, and S. B. Nair, ***Artificial Intelligence***, 3rd Edition, McGraw Hill, 2017.
R2. N. J. Nilson, ***Principles of Artificial Intelligence***, 1st Edition, Narosa, 2002.

Online Resources:

1. https://nptel.ac.in/courses/106102220: by Prof. Mausam, IIT Delhi
2. https://nptel.ac.in/courses/106/105/106105079/: by Prof. P. Dasgupta, IIT Kharagpur
3. https://nptel.ac.in/courses/106/106/106106126/: by Prof. D. Khemani, IIT Madras

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore agents & environments, analyze classical search problems, and search the state space of problems using uninformed techniques.
CO2	Apply informed search, adversarial search (game playing) and constraint satisfaction problems.
CO3	Interpret propositional and first order logic, deduce from knowledge-base using resolution and forward backward chaining, represent knowledge using semantic nets & frames.
CO4	Apply planning and reasoning to handle uncertainty in real life problems.
CO5	Use learning to solve complex real-life problems, and understand communication, perception and basics of intelligent robotic systems.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2							1	3	3	3
CO2	3	3	2							1	3	3	3
CO3	3	3	3							1	2	1	2
CO4	3	3	2							1	1	1	3
CO5	2	2	2							1	1	1	3

Type	Code	Internet of Things	L-T-P	Credits	Marks
PE	MTCS-T-PE-008		3-0-0	3	100

Objectives	The objective of this course is to study the concepts, technologies, design principles, challenges, and case-studies of Internet of Things to enable for designing IoT applications targeting real world problems.
Pre-Requisites	Basic knowledge of computer networks, sensor networks, micro-processor and micro-conrollers are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on designing for IoT & real-life applications.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to IoT: Definition, Characteristic, Components of IoT, Design of IoT systems, Technology and systems implementing IoT, Levels of IoT, Sensors, Actuators, Power Supply.	**8 Hours**
Module-2	IoT Network Model: OSI reference model, Layers in IoT; Protocols: MAC based Protocols, IP-based Protocols, Simple Network Management Protocol (SNMP), NetConf, Yang.	**9 Hours**
Module-3	M2M: IoT vs. M2M, Software Defined Networking, Network Function Virtualization; IoT Platform Design: IoT Design Methodology, Resource management in IoT, Data Synchronization, Emerging IoT Standards.	**9 Hours**
Module-4	Performance Modeling & Device Analysis: Zigbee, Bluetooth, Wi-fi, RFID, Cloud Computing, Big Data.	**8 Hours**
Module-5	Open Problems & Research challenges: IoT in Smart Home, Smart Grid, Agriculture, Healthcare, Industrial IoT (IIoT), Industrial Internet Consortium (IIC), Environment, Smart Cities, IoT Security.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. Bahga and V. Madisetti, ***Internet of Things - A Hands on Approach***, University Press, 2014.
T2. O. Hersent, D. Boswarthick, and O. Elloumi, ***The Internet of Things : Key Applications and Protocols***, Student Edition, John Wiley & Sons, 2016.

Reference Books:

R1. D. Uckelmann, M. Harrison, and F. Michahelles, ***Architecting the Internet of Things***, Springer, 2014.
R2. R. Buyya and A. V. Dastjerdi, ***Internet of Things Principle and Paradigms***, Elsevier, 2016.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105166/: by Prof. S. Misra, IIT Kharagpur
2. https://nptel.ac.in/courses/108/108/108108098/: by Prof. T. V. Prabhakar, IIScBangalore
3. https://iot-analytics.com/: Online repository for IoT analytics topics.
4. https://www.ibm.com/internet-of-things: IBM Watson IoT platform

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the vision & design of IoT and its architecture from a global context.
CO2	Explain communication between sensors and systems using various protocols and network models.
CO3	Differentiate between IoT & M2M and design IoT platforms using different devices, gateways with data management methodology.
CO4	Describe real-time applications of IoT concepts applied in various devices to build systems using architectures for IoT.
CO5	Apply IoT in industrial and commercial automation with real-world design constraints.

Program Outcomes Relevant to the Course:

PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1			3	3	1					1	1	1	1
CO2				2	2					1	2	2	3
CO3			3	3	2					1	2	2	2
CO4			3	2						1	2	2	2
CO5			3	3	1					2	2	3	3

Type	Code	Embedded Systems	L-T-P	Credits	Marks
PE	MTCS-T-PE-009		3-0-0	3	100

Objectives	The objective of this course is to study the concepts & architecture of embedded systems including ARM architecture, real-time operating systems, hardware-software co-simulation, hardware-software partitioning, and low power embedded systems design.
Pre-Requisites	Knowledge of operating systems, computer organization and architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as required, sessions are planned to be interactive with focus on examples, case-studies, and latest trends.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Embedded Systems: Applications, Classifications and Characteristics of Embedded Systems, Processors, Hardware units and Devices embedded into a system, Embedded software in a system, Embedded System-on-Chip (SoC), Design metrics, System design approach to embedded systems.	**8 Hours**
Module-2	ARM: ARM microcontroller, Stages of evolution of ARM Family, Different versions of pipelines in ARM, Instruction Set Architecture (ISA), THUMB instructions, Exceptions in ARM, Programming Examples.	**8 Hours**
Module-3	Interfacing: Serial Peripheral Interface (SPI), I^2C, RS-232C, RS-422, RS-485, USB, USB interface and connectors, IrDA, CAN, Bluetooth, ISA, PCI.	**7 Hours**
Module-4	Real-Time Operating Systems: Real-time task scheduling concepts, Types and Characteristics of real time tasks, Task scheduling, Clock-driven scheduling, Event-driven scheduling, EDF, RMA, Resource sharing using PIP, HLP and PCP, Features of real-time operating system: UNIX as a RTOS, POSIX, Other Commercial RTOS like PSOS, VRTX, Lynx, and Windows CE.	**10 Hours**
Module-5	Specification Techniques: State chart, SDL, Petri-Nets, UML; Hardware-Software Co-simulation: Design, approaches and co-simulation environment; Hardware-Software Partitioning: Integer programming, K-L partitioning, Partitioning using GA; Low Power Embedded System Design: Dynamic and Static power dissipation, Power reduction, Algorithmic and Control Logic power minimization, System level Power Management.	**9 Hours**
	Total	**42 Hours**

Text Books:

T1. F. Vahid and T. Givargis, ***Embedded Systems Design: : A Unified Hardware / Software Introduction***, Student Edition, Wiley India, 2002.
T2. S. Chattopadhyay, ***Embedded System Design***, 2nd Edition, Prentice Hall India, 2013.
T3. R. Mall, ***Real-Time Systems***, 2nd Edition, Pearson Education, 2010.

Reference Books:

R1. P. Marwedel, ***Embedded System Design***, 1st Edition, Springer, 2006.
R2. R. Kamal, ***Embedded System Architecture, Programming and Design***, 3rd Edition, Tata McGraw-Hill, 2017.

Online Resources:

1. https://nptel.ac.in/courses/106/105/106105159/: by Prof. A. Basu, IIT Kharagpur
2. https://nptel.ac.in/courses/108/105/108105057/: by Prof. R. Mall, Prof. A. Patra, and Prof. A. Routray, IIT Kharagpur
3. https://nptel.ac.in/courses/108/102/108102045/: by Prof. S. Chaudhary, IIT Delhi
4. https://nptel.ac.in/courses/106/105/106105193/: by Prof. I. Sengupta and Prof. K. Datta, IIT Kharagpur

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the architecture, components, hardware & software of embedded systems.
CO2	Explain the ARM architecture, its instruction set, and features.
CO3	Explain & analyze device drivers and their interfacing in embedded systems.
CO4	Visualize real-time operating systems and analyze task-scheduling algorithms.
CO5	Model embedded systems using various techniques and minimizes power consumption.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1	2		2					1	1	1	2
CO2	2	2	2		2					1	1	2	2
CO3	3	2	2	2	3					1	2	2	3
CO4	2	3	2	2	3		2			1	2	2	2
CO5	3	1	3	2	2	2	1			2	2	2	2

Type	Code	English for Research Paper Writing	L-T-P	Credits	Marks
MC	MTBS-T-MC-009		2-0-0	0	100

Objectives	The objective of this course is to give learners an exposure to different aspects of research related technical writing and to help them write such matter effectively through practice.
Pre-Requisites	Basic knowledge of English grammar and the ability to read and write using the English language.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on technical writing activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Technical Communication: Differentiating between general and technical writing, purpose of writing, plain English, mechanics of writing, elements of style. Essentials of English Grammar: basic word order, tense forms, reported speech, use of passives, conditionals, concord, clauses, common errors.	**9 Hours**
Module-2	Elements of Writing: Process writing, developing an effective paragraph, qualities of a paragraph, structuring a paragraph, types of essays, writing reports.	**5 Hours**
Module-3	Key Reading Skills: sub-skills of reading, local and global comprehension, types of technical texts, critical analysis of technical texts, note-making, the purpose and importance of literature review, evaluating literature.	**5 Hours**
Module-4	Developing Writing Skills: writing abstracts, technical letters, project reports, elements of proposal writing.	**6 Hours**
Module-5	Research and Writing: The research paper as a form of communication, Writing a review of Literature, developing a hypothesis, formulating a thesis statement, plagiarism issues.	**3 Hours**
	Total	**28 Hours**

Text Books:

T1. C. Ellison, ***McGraw-Hill's Concise Guide to Writing Research Papers***, McGraw-Hill, 2010.
T2. A. Wallwork, ***English for Writing Research Papers***, Springer, 2011.
T3. R. A. Day, ***How to Write and Publish a Scientific Paper***, 7th Edition, Greenwood, 2011.

Reference Books:

R1. R. Goldbort, ***Writing for Science***, Yale University Press, 2006.
R2. N. J. Higham, ***Handbook of Writing for the Mathematical Sciences***, 2nd Edition, SIAN, 1998.
R3. C. R. Kothari & G. Garg, ***Research Methodology: Methods and Techniques***, 2nd Edition, New Age International Publishers, 2014.

P.T.O

Online Resources:

1. https://msu.edu/course/be/485/bewritingguideV2.0.pdf: Michigan State University Press, USA, Technical Writing Guide, 2007.
2. http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf: Sentence Structure of Technical Writing, Nicole Kelley, MIT, USA, 2006.
3. http://www.inf.ed.ac.uk/teaching/courses/pi/2017_2018/slides/Technical-Writing-Basics.pdf: Notes from Pocketbook of Technical Writing for Engineers and Scientists by Leo Finkelstein, NY, 2007.
4. https://www.shs-conferences.org/articles/shsconf/pdf/2016/04/shsconf_erpa2016_01090.pdf: A need analysis of technical writing skill of engineering students in India, JCK Evangeline & K. Ganesh, DOI: 10.1051/ shsconf/20162601090, 2016

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Understand the importance and application of technical communication and apply essentials of English grammar to make research writing effective.
CO2	Apply the elements of technical writing to produce effective research papers.
CO3	Develop critical reading and analysis skills of technical research papers and texts.
CO4	Develop the ability to write technical articles and effectively present the ideas.
CO5	Develop research acumen by understanding the key skills of research.

Program Outcomes Relevant to the Course:

PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1						3	1	1	3	3	1	2	3
CO2						3			3	3	1	2	3
CO3						3	1	1	3	3	2	2	3
CO4						2		1	3	3	2	2	3
CO5						2	1	3	3	3	2	2	3

Type	Code	Machine Learning Lab	L-T-P	Credits	Marks
PC	MTCS-P-PC-007		0-0-2	1	100

Objectives	The objective of this course is to hands-on exposure on feature extraction used in machine learning applications, experimentally compare different machine learning techniques in real-world problems.
Pre-Requisites	Knowledge of optimization and matrix theory and proficiency in a computer programming language are required.
Teaching Scheme	Regular laboratory experiments executed by the students under supervision of the teacher. Experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Overview of Scikit-Learn.
2	Experiment demonstrating simple and multiple linear regression.
3	Experiment on binary classification using Logistic regression.
4	Application of Linear discriminant analysis.
5	Program on Ridge regression.
6	Experiment on Cross-validation and boot strap.
7	Program on Fitting classification and regression trees.
8	Program on K-nearest neighbors.
9	Experiment on Principal component analysis.
10	Program demonstrating K-means clustering.
11, 12	Implementation of Perceptron Learning.
13, 14	Implementation of Deep Neural Network with Backpropagation.

Text Books:

T1. T. Hastie, R. Tibshirani, J. Friedman, ***The Elements of Statistical Learning: Data Mining, Inference and Prediction***, 2nd Edition, Springer Verlag, 2009.
T2. C. Bishop, ***Pattern Recognition and Machine Learning***, Springer, 2007.

Reference Books:

R1. K. P. Murphy, ***Machine Learning: A Probabilistic Perspective***, 4th Edition, MIT Press, 2012.
R2. H. Daumé III, ***A Course in Machine Learning***, Free e-Book, 2015.
R3. T. Mitchel, ***Machine Learning***, McGraw-Hill Science, 1997.
R4. S. Shalev-Shwartz and S. Ben-David, ***Understanding Machine Learning: From Theory to Algorithms***, Cambridge University Press, 2014.

Online Resources:

1. http://mlss.cc/: Machine Learning Summer School Study Material.
2. https://github.com/josephmisiti/awesome-machine-learning: An exhaustive index of machine learning concepts and programming materials.

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Become familiar with different Machine Learning toolkits.
CO2	Apply basic machine learning algorithms for predictive modeling.
CO3	Compare and contrast pros and cons of various machine learning techniques.
CO4	Extract meaningful data using non-statistical modeling with special emphasis on real world applications.
CO5	Implement recent advances in the field of machine learning, especially deep learning.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	2	1	3	2					1	2	2	3
CO2	2	2	2	3	2		2			2	2	2	2
CO3	3	3	3	3	2		2			2	1	1	2
CO4	3	3	3	3	3		2			3	2	2	3
CO5	3	3	3	3	3		2			3	2	2	3

Type	Code	Scalable Database Systems Lab	L-T-P	Credits	Marks
PC	MTCS-P-PC-009		0-0-4	2	100

Objectives	The objective of this course is to provide hands-on practice on storage, retrieval and manipulation of relational data using SQL, along with other data models & query languages on some of the popular NoSQL databases.
Pre-Requisites	Knowledge of databases and programming skills is required.
Teaching Scheme	Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments.

Evaluation Scheme

Attendance	Daily Performance	Lab Record	Lab Test/ Mini Project	Viva-voce	Total
10	30	15	30	15	100

Detailed Syllabus

Experiment-#	Assignment/Experiment
1	Introduction to relational databases, data types, and syntax of SQL
2	Data retrieval using simple queries based on conditions and sorting the results.
2	Single-row functions, grouping and aggregate functions in SQL queries.
3	Writing complex queries using sub-queries and co-related sub-queries.
4	Create database, create tables, alter and manipulate structure of tables.
5	Imposing various constraints on tables for maintaining data integrity.
6	Insert, Update, and Delete data in the tables (DML statements).
7	Retrieve data from multiple tables using various types of Join operations.
8	Create, alter, and manage Views from single & multiple base tables.
9	Create and use other data base objects like sequence, indexes, and synonyms.
10	Performing set operations on tables, advanced operations like rollup and cube.
11	Introduction to PL/SQL, identifiers, literals, and keywords.
12	Write PL/SQL block by using conditional statements and expressions.
13	Using different types of Loops in a PL/SQL block and Exception handling.
14	Write PL/SQL block by using numeric, string, and other miscellaneous data types.
14	Write PL/SQL block to retrieve data using cursors.
16	Introduction to Stored procedures, Write PL/SQL block using procedures.
17	Develop functions with in/out parameters and using them in a PL/SQL block.
18	Write PL/SQL block using package and trigger.
19	Introduction to NoSQL databases, Document & Graph data models.
20	MongoDB - Introduction to MQL, Data Definition - Create, Alter, Drop, Truncate.
21	MongoDB - Data Manipulation - Select, Insert, Update, Delete, Batch.
22	MongoDB - Aggregate Framework, executing advanced queries.
23	Cassandra - Introduction to CQL, Create database, Create tables, Insert data.
24	Cassandra - Data retrieval and manipulation using CQL.

Cont'd...

Experiment-#	Assignment/Experiment
25	Cassandra - Indexes and Materialized Views.
26	Neo4j - Introduction to GQL (Cypher), Design & implement graph database.
27	Neo4j - Executing simple queries on graph databases.
28	Neo4j - Executing complex pattern queries on graph databases.

Text Books:

T1. K. Loney, ***Oracle Database 11g : The Complete Reference***, 1st Edition, McGraw-Hill, 2009.
T2. S. Bradshaw, E. Brazil, and K. Chodorow, ***MongoDB: The Definitive Guide***, 3rd Edition, O'Reilly Media, 2019.
T3. E. Hewitt, ***Cassandra: The Definitive Guide***, 1st Edition, O'Reilly Media, 2010.
T4. R. V. Bruggen, ***Learning Neo4j 3.x***, 1st Edition, Packt Publishing, 2014.

Reference Books:

R1. I. Bayross, ***Teach Yourself SQL/PLSQL Using Oracle 8i and 9i with SQLJ***, 1st Edition, BPB Publications, 2003.
R2. S. Feuerstein, ***Oracle PL/SQL Programming***, 6th Edition, O'Reilly, 2014.
R3. S. Tiwari, ***Professional NoSQL***, 1st Edition, Willey, 2011.
R4. D. Bechberger and J. Perryman, ***Graph Databases in Action***, 1st Edition, Manning Publications, 2020.

Online Resources:

1. https://docs.oracle.com/cd/E11882_01/server.112/e40402/toc.htm
2. https://docs.mongodb.com/
3. https://cassandra.apache.org/doc/latest/
4. https://neo4j.com/docs/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Construct queries using SQL and retrieve data from a database using single/multi-row functions, and sub-queries.
CO2	Design relational tables imposing integrity constraints, operate on and manipulate database tables using DDL/DML statements.
CO3	Create other database objects like views, sequences and indices.
CO4	Develop complex PL/SQL programs including control structures, procedures, functions and triggers for real life applications.
CO5	Implement different types of NoSQL databases for unstructured data as per real-world requirements and analyze the data using NoSQL query languages.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.

Cont'd...

PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	1									1	2	2
CO2	2	2				1					2	2	2
CO3	2	2	1		1	1				1	2	2	2
CO4	1	3	2		2	1			1	2	2	3	3
CO5	2	3	3		3	2			2	3	2	3	3

Part II

2nd Year M.Tech. (CSE)

Curriculum Structure

Semester III									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
THEORY									
PE		Professional Elective-IV	3	0	0	3	0	0
PE		Professional Elective-V	3	0	0	3	0	0
OO		MOOC	3	0	0	3	0	0
PRACTICAL									
PJ	MTCS-P-PJ-001	Thesis (Part - I) & Seminar	0	0	12	0	0	6
PJ	MTII-P-PJ-002	Summer Internship	0	0	0	0	0	1
		SUB-TOTAL	**6**	**0**	**12**	**9**	**0**	**7**
		TOTAL	**18**			**16**		

Semester IV									
Type	**Code**	**Course Title**	**WCH** L-T-P			**Credits** L-T-P		
PRACTICAL									
PJ	MTCS-P-PJ-003	Thesis (Part - II) & Seminar	0	0	28	0	0	14
MC	MTBS-P-MC-001	Yoga/NCC/NSS	0	0	2	0	0	0
		SUB-TOTAL	**0**	**0**	**30**	**0**	**0**	**14**
		TOTAL	**30**			**14**		

		GRAND TOTAL (4 SEMESTERS)	**96**	**68**

Note:

1. *MOOC - Massive Open Online Course.*
2. *Approved list of courses for MOOC (self study) shall be published by the department.*
3. *Courses offered under each elective are given in "List of Electives" on Page 52.*

List of Electives

Code	Elective # and Subjects
Professional Elective-IV	
MTCS-T-PE-010	Data Security & Privacy
MTCS-T-PE-011	Cloud Computing
MTCS-T-PE-012	Parallel & Distributed Systems
Professional Elective-V	
MTCS-T-PE-013	Natural Language Processing
MTCS-T-PE-014	Data Visulization
MTCS-T-PE-015	Blockchain Technology

Type	Code	Data Security & Privacy	L-T-P	Credits	Marks
PE	MTCS-T-PE-010		3-0-0	3	100

Objectives	The objective of this course is to study the concepts of security, types of attacks, encryption & authentication techniques and their application to network and internet security.
Pre-Requisites	Knowledge on linear algebra, algorithms, computer networks, and internet technologies is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Security: Need for security, Security approaches, Principles of Security, Types of attacks; Encryption Techniques: Plaintext, Cipher text, Substitution & Transposition Techniques, Encryption & Decryption, Key range & size.	**8 Hours**
Module-2	Symmetric Key Cryptography: Algorithm types & Modes, AES and its analysis, Differential & Linear Cryptanalysis; Asymmetric Key Cryptography: RSA and El-Gamal cryptosystems, Elliptic Curve Arithmetic, ECC operations, Applications of ECC in asymmetric cryptography.	**8 Hours**
Module-3	Cryptographic Hash Function: Random Oracle Model, Cryptographic Hash Functions: SHA-512, MD5, Pseudo Random Number Generation using Hash Function, Message Authentication Code: HMAC, Digital Signature; User Authentication Mechanism: Authentication basics, Passwords, Authentication tokens, Certificate based & Biometric authentication.	**10 Hours**
Module-4	Network and Web Security: Network Security Attacks, Distributed Denial of Service(Botnet), Intrusion Detection & Prevention Systems, Firewall, Browser Attacks, Obtaining user or website data, Web attack targeting users, E-mail attacks and security.	**8 Hours**
Module-5	Blockchain: Introduction to Blockchain, Consensus Protocols, Blockchain use cases, Soft fork vs. Hard fork, Zero Knowledge Proof (ZKP), Smart Contracts, DApps.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. D. R. Stinson, ***Cryptography: Theory and Practice***, 3rd Edition, CRC Press, 2005.
T2. C. P. Pfleeger, S. L. Pfleeger, and J. Margulies, ***Security in Computing***, 5th Edition, 2015.
T3. A. Banafa, ***Blockchain Technology and Applications***, 1st Edition, 2020.

Reference Books:

R1. W. Stallings, ***Cryptography and Network Security: Principle and Practice***, 7th Edition, Pearson Education, 2017.

R2. B. A. Forouzan, D. Mukhopadhaya, ***Cryptography and Network Security***, 2nd Edition, McGraw-Hill Education, 2010.
R3. A. J. Menezes, P. C. Van Oorschot, and S. A. Vanstone, ***Handbook of Applied Cryptography***, CRC Press, 1996.
R4. B. Schneier, ***Applied Cryptography: Protocols, Algorithms, and Source Code in C***, 2nd Edition, Wiley, 2007.

Online Resources:

1. https://nptel.ac.in/courses/106105031/: by Dr. D. Mukhopadhyay, IIT Kharagpur
2. https://nptel.ac.in/courses/106105162: by Prof. S. Mukhopadhyay, IIT Kharagpur
3. https://nptel.ac.in/courses/106106221: by Prof. A. Choudhury, IIIT Bangalore
4. https://nptel.ac.in/courses/106104220: by Prof. S. Shukla, IIT Kanpur
5. https://www.cs.bgu.ac.il/~dsec121/wiki.files/j21.pdf: Survey of Web Security
6. www.uky.edu/~dsianita/390/firewall1.pdf: A Simple Guide to Firewalls
7. https://www.cryptool.org/en/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe the basics of security & issues related to it, encryption & decryption techniques.
CO2	Explain symmetric and asymmetric key cryptography and analysis of AES , RSA and ECC.
CO3	Explain cryptographic hash functions and their application to authentication and digital signatures.
CO4	Analyze the security issues in computer networks, web applications, and their mitigation.
CO5	Explore blockchain technology and its applications in context of data privacy.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	1	2							2	2	2
CO2	3	2	2	2	2						2	2	3
CO3	3	3	2	2	2						2	2	3
CO4	1	2	3	2	2		2				2	2	3
CO5	1	2	3	2	2		2				3	3	3

Type	Code	Cloud Computing	L-T-P	Credits	Marks
PE	MTCS-T-PE-011		3-0-0	3	100

Objectives	The objective of this course is to learn the fundamental concepts of cloud computing, its architecture, different models, privacy and security provisioning issues and methods, auditing and performance analysis of different application specific models deployed in a cloud.
Pre-Requisites	Knowledge of computer networks, client-server concepts, and server side programming are required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Overview of Computing Paradigm: P2P, Grid, Cluster, Distributed, Utility, and Cloud Computing; Evolution of computing, adopting cloud computing in business; Introduction to cloud computing: NIST Model, Properties, Characteristics, Benefits, Role of open standards.	**9 Hours**
Module-2	Cloud Computing Architecture: The cloud computing stack (Client/Server, Protocols, Web services), Service Models (XaaS): IaaS, PaaS, SaaS; Deployment Models: Public, Private, Hybrid, Community; Platform as a Service: Overview of PaaS, Service Oriented Architecture (SOA); Cloud platform and management, Computation and storage; Case Study: Google App Engine, Microsoft Azure, SalesForce.com - platform and use for public.	**8 Hours**
Module-3	Infrastructure as a Service: IaaS definition, Introduction to Virtualization, Hypervisors, Machine Image, Virtual Machine; Resource Virtualization of server, storage, network; Case Study: Amazon EC2- Renting, EC2 Compute Unit, platforms and storage, pricing, Customer Service Provisioning; Eucalyptus.	**9 Hours**
Module-4	Software as a Service: Introduction to SaaS, Web services, Web 2.0, Web OS, Case Study on SaaS; Service Management: Service Level Agreements, Billing & Accounting, Comparing Scaling Hardware- Traditional vs. Cloud, Economics of Scaling, Managing Data- Database & Data Stores in Cloud, large scale data processing.	**8 Hours**
Module-5	Cloud Security: Infrastructure Security, Network level, Host level, Application Level, Data Security, Identity and Access Management, Access Control, Trust, Reputation, Risk; Authentication: Client access in Cloud, Cloud contracting model, commercial and business considerations, Service level maintenance in Infrastructure, Network, Host and Application; Case Study: Eucalyptus, Microsoft Azure, Amazon EC2.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. R. Buyya, J. Broberg, and A. Goscinski, ***Cloud Computing: Principles and Paradigms***, 2nd Edition, Wiley, 2011.
T2. G. Shroff, ***Enterprise Cloud Computing - Technology, Architecture, Applications***, University Press, 2010.
T3. R. L. Krutz and R. D. Vines, ***Cloud Security: A Comprehensive Guide to Secure Cloud Computing***, Wiley-India, 2010.

Reference Books:

R1. B. Sosinsky, ***Cloud Computing Bible***, Wiley-India, 2010.
R2. N. Antonopoulos and J. Gilam, ***Cloud Computing: Principles, Systems and Applications***, Springer, 2012.
R3. T. Mather, S. Kumaraswamy, and S. Latif, ***Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance***, 1st Edition, O'Reilly Media, 2009.
R4. A. T. Velte, T. J. Velte, and R. Elsenpeter, ***Cloud Computing: A Practical Approach***, Tata McGraw-Hill, 2010.

Online Resources:

1. https://nptel.ac.in/courses/106105167: by Prof. S. K. Ghosh, IIT Kharagpur
2. https://nptel.ac.in/courses/106105223: by Prof. S. K. Ghosh, IIT Kharagpur
3. https://nptel.ac.in/courses/106104182: by Dr. Dr.R. Misra, IIT Patna
4. https://www.coursera.org/learn/cloud-computing: Prof. I. Gupta, Dept. of CS, University of Illinois at Urbana-Champaign
5. http://web.mit.edu/6.897/www/readings.html: by Prof. H. Balakrishnan, MIT

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Describe different types of computing paradigms, differentiate between them, acquire knowledge on cloud standards and their various application areas.
CO2	Visualize cloud computing architecture, service models, deployment models, service platforms with respect to computation and storage.
CO3	Explain virtualization of machine, resources, servers, storage, and network, with a case study of Amazon EC2, pricing models, and service provisioning.
CO4	Describe Software as a Service, service level agreement, how to manage data, large scale processing in cloud environment.
CO5	Explain infrastructure, network, host, application, data, identity level security in cloud computing security models and commercial & business reliability models from different case studies of popular cloud service providers.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO8	Understand intellectual property rights and overall professional & ethical responsibility.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	3				1	1		1	2	2	3
CO2	3	2	3	1			1	1		1	2	2	2
CO3	3	3	3	2			3	2		1	3	3	3
CO4	3	3	3	3			3	3		1	3	2	3
CO5	3	2	3	3			3	2		3	3	3	3

Type	Code	Parallel & Distributed Systems	L-T-P	Credits	Marks
PE	MTCS-T-PE-012		3-0-0	3	100

Objectives	The objective of this course is to study the fundamentals and design issues of parallel & distributed systems and related technologies.
Pre-Requisites	Basic knowledge of Computer Architecture is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and case studies.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction: Parallel and Distributed Computing, Flynn's Taxonomy of Parallel Architectures: Parallel/Vector Computers, Shared Memory Multiprocessors (UMA, NUMA, COMA), Distributed Memory Multiprocessors, Multivector and SIMD computers, Data Parallel Pipelined and Systolic Architectures, Instruction set Architectures (CISC, RISC, VLIW, super pipelined, vector processors),Performance Evaluation of Computer Systems, PRAM Model of Parallel Computation, PRAM Algorithms: Parallel Reduction, List Ranking, Preorder tree traversal.	**9 Hours**
Module-2	Interconnection Networks: Static, Dynamic Interconnection Networks, Analysis and performance Metrics. Comparison of Topologies: The Moore Bound, Routing in Static Networks: Topology independent Routing (Point-to-Point routing, Broadcasting, Gossiping), Topology dependent routing.	**9 Hours**
Module-3	Communication: Layered Protocols, Types of Communication, Remote Procedure Call: Basic RPC Operation, Parameter Passing, Asynchronous RPC, Message-Oriented Communication: Message-Oriented Transient Communication, Message-Oriented Persistent Communication, Stream Oriented Communication: Support for Continuous Media, Streams and Quality of Service, Stream Synchronization. Basic Communication Operations: One-to-All, All-to-All Broadcast and Reduction, All-to-All Personalized Communication.	**8 Hours**
Module-4	Processes & Threads: Introduction to Threads, Threads in Distributed Systems, Clients, Server Clusters, Managing Server Clusters, Flat Naming, Structured Naming, Attribute-Based Naming: Directory Services, Hierarchical Implementations: LDAP, Decentralized Implementations.	**8 Hours**
Module-5	Distributed Object Based Systems: Distributed Objects, Enterprise Java Beans (EJB), Globe Distributed Shared Objects, Object Servers, Binding a Client to an Object, Static versus Dynamic Remote Method Invocations, Parameter Passing, Java RMI, Object-Based Messaging, CORBA Object References, Globe Object References, Synchronization, Consistency and Replication, Fault Tolerance, Security.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. A. S. Tanenbaum and M. V. Steen, ***Distributed Systems: Principles and Paradigms***, 2nd Edition, PHI Learning, 2011.

T2. A. Grama, A. Gupta, G. Karypis, and V. Kumar, ***Introduction to Parallel Computing***, 2nd Edition, Pearson Education, 2003.

Reference Books:

R1. K. Hwang and N. Jotwani, ***Advanced Computer Architecture: Parallelism, Scalability, Programmability***, 3rd Edition, Tata McGraw-Hill, 2017.

R2. A. Kulkarni, N. P. Giri, N. Joshi, and B. Jadhav, ***Parallel and Distributed Systems***, 2nd Edition, Wiley, 2017.

R3. G. Kotsis, ***Interconnection Topologies and Routing for Parallel Processing Systems***, Technical Report Series, ACPC/TR 92-19, 1992.

Online Resources:

1. https://nptel.ac.in/courses/106106107: by Prof. V. S. Ananthanarayana, IIT Madras
2. https://courses.cs.washington.edu/courses/cse552/07sp/
3. https://henryr.github.io/distributed-systems-readings/
4. https://www.ccs.neu.edu/home/gene/par-resources.html
5. http://www.transputer.net/fbooks/gk_dipl/gk_dipl.pdf

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the goals and design issues of parallel and distributed systems.
CO2	Design and performance analysis of interconnection networks.
CO3	Explain RPC and describe message & stream oriented communication.
CO4	Describe design issues of server and naming entities in a distributed system.
CO5	Explore distributed object based systems and distinguish between CORBA, EJB and GLOBE.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	1	2	3	2	1					2	2	3
CO2	2	2	1	1		1					2	2	2
CO3	1	2	2	3	1						2	2	3
CO4	2	2	2	2							2	2	2
CO5	1	3	2	2	2	1					2	3	3

Type	Code	Natural Language Processing	L-T-P	Credits	Marks
PE	MTCS-T-PE-013		3-0-0	3	100

Objectives	The objective of this course is to study fundamentals, algorithms, and techniques to enable processing of natural languages by computers in order to design different human-computer interactive systems.
Pre-Requisites	Knowledge on grammar rules, statistics, automata theory and machine learning techniques is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Natural Language Processing, various applications, issues and processing complexities, Regular Expressions, Text Normalization, Edit Distance, N-gram Language Models, Smoothing techniques.	**8 Hours**
Module-2	Naïve Bayes and Sentiment Classification, Other text classification task and logistic regression, Vector Semantics and Embeddings, Sequence Labeling for Parts of Speech and Named Entities.	**8 Hours**
Module-3	Deep Learning Architectures for Sequence Processing, Recurrent neural networks applied to language problem, Contextual Embeddings, Machine Translation and Encoder-Decoder Models.	**8 Hours**
Module-4	Constituency Grammars, Constituency Parsing, Dependency Parsing, Logical Representations of Sentence Meaning, Computational Semantics and, Semantic Parsing, Information Extraction.	**8 Hours**
Module-5	Word Senses and WordNet, Coreference Resolution, Discourse Coherence, Question Answering, Chatbots and Dialogue Systems, Automatic Speech Recognition, Text-to-Speech.	**10 Hours**
	Total	**42 Hours**

Text Books:

T1. D. Jurafsky and J. H. Martin, ***Speech and Language Processing - An Introduction to Language Processing, Computational Linguistics, and Speech Recognition***, 2nd Edition, Pearson Education, 2003.
T2. C. D. Manning and H. Schütze, ***Foundations of Statistical Natural Language Processing***, 2nd Edition, MIT Press, 2000.

Reference Books:

R1. T. Siddiqui and U. S. Tiwary, ***Natural Language Processing and Information Retrieval***, 1st Edition, Oxford University Press, 2008.
R2. C. C. Aggarwal, ***Machine Learning for Text***, 1st Edition, Springer, 2018.
R3. J. Allen, ***Natural Language Understanding***, 2nd Edition, Pearson Education, 2008.

Online Resources:

1. https://nptel.ac.in/courses/106/101/106101007/: by Prof. P. Bhattacharyya, IIT Bombay
2. https://nptel.ac.in/courses/106/105/106105158/: by Prof. P. Goyal, IIT Kharagpur
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-863j-naturallanguage-and-the-computer-representation-of-knowledge-spring-2003/lecture-notes/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the text pre-processing techniques for natural language processing.
CO2	Apply machine learning techniques to text classification task and sequence labeling.
CO3	Apply deep-learning technques for sequence and other language processing tasks.
CO4	Perform semantic level analysis on natural language processing applications.
CO5	Perform discourse level analysis and appreciate advanced applications of NLP with applied machine learning techniques.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	3	2	2	2	3					2	2	2	1
CO2	3	3	3	2	3					3	3	3	2
CO3	3	3	3	2	3					3	3	3	3
CO4	3	3	3	2	3					3	3	3	3
CO5	3	3	3	2	3					3	3	3	3

Type	Code	Data Visualization	L-T-P	Credits	Marks
PE	MTCS-T-PE-014		3-0-0	3	100

Objectives	The objective of this course is to introduce the design principles and techniques for interactively visualizing data and its analysis in graphical manner for proper understanding. This course involves theories, techniques, strategies, and tools for constructing information visually.
Pre-Requisites	Basic knowledge of graphs & charts, and programming in Python/R is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with programming and problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	What is Visualization? The visualization process. Seven stages of data visualization, Types of data, Perception, Eight visual variables: position, shape, size, brightness, color, orientation, texture, motion.	**8 Hours**
Module-2	Visualization Techniques for Multivariate data, Tree, Graph, Networks, Text, Documents.	**8 Hours**
Module-3	Visualization Techniques for Spatial data, Geospatial data, Time-oriented data, Evaluating Visualizations.	**8 Hours**
Module-4	Introduction to D3, Working with data, Data-binding, Data-driven design and interaction, General charting principles, creating an axis, line charts and interpolations, Layouts (Histograms, Pie charts, Stack layout), Visualization with SVG, Drawing - Transformations - Building Chart with SVG (Scalable Vector Graphics).	**10 Hours**
Module-5	Visualization libraries in R/Python: Matplotlib (Histograms, Bar Charts, Line plots, Pie Charts, Box Plots, Scatter Plots), Seaborn (Box, Violin Plots, Regression Plots, Heatmaps), Bokeh, ggplot2, Creating Dashboards with Plotly and Dash.	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. M. Ward, G. Grinstein, and D. Keim, ***Interactive Data Visualization : Foundations, Techniques, and Applications***, 2nd Edition, CRC Press, 2015.
T2. E. Meeks, ***D3.js in Action : Data Visualization with JavaScript***, 2nd Edition, Manning Publications, 2018.
T3. A. C. Telea, ***Data Visualization Principles and Practice***, 2nd Edition, CRC Press, 2015.

Reference Books:

R1. B. Fry, ***Visualizing Data***, O'Reilly Media, 2007.
R2. S. Murray, ***Interactive Data Visualization for the Web***, 2nd Edition, O'Reilly Media, 2017.
R3. K. Sosulski, ***Data Visualization Made Simple : Insights Into Becoming Visual***, Routledge, 2018.
R4. K. Healy, ***Data Visualization : A Practical Introduction***, Princeton University Press, 2019.

Online Resources:

1. https://1lib.in/book/2551564/b19e0b
2. https://1lib.in/book/5216746/8f8e9b
3. https://matplotlib.org/stable/tutorials/index.html
4. https://seaborn.pydata.org/tutorial.html
5. https://docs.bokeh.org/en/latest/docs/gallery.html
6. https://www.r-graph-gallery.com/ggplot2-package.html

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explore the use of data visualization and perceptions.
CO2	Determine appropriate visualization techniques for one, two and multi-dimensional data.
CO3	Create visualizations for complex data and evaluate the visualization techniques.
CO4	Build interactive graphs and charts with D3.js and Scalable Vector Graphics.
CO5	Develop programs using Python/R libraries for interactive data visualization.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO6	Function effectively as an individual or as a part of a multi-disciplinary team to accomplish defined goals.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.
PO9	Communicate effectively in a technically sound manner with a wide range of audience.
PO10	Continue to learn independently and engage in life-long learning.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	1	2		3	1	1	1	2
CO2	1	2	3	2	2	1	1		2	1	2	2	2
CO3	1	1	2	1	2	1	2		2	1	2	2	2
CO4			1	1	2				2	1	1	2	2
CO5			2	2	2	2	1		2	1	3	3	3

Type	Code	Blockchain Technology	L-T-P	Credits	Marks
PE	MTCS-T-PE-015		3-0-0	3	100

Objectives	The objective of this course is to study the blockchain technology and its applications in various domains with primary focus on Blockchain basics, consensus protocols, smart contracts, and security issues.
Pre-Requisites	Basic knowledge of networks, cryptography, and programming is required.
Teaching Scheme	Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with programming and problem solving activities.

Evaluation Scheme

Teacher's Assessment			Written Assessment		Total
Quiz	Surprise Test(s)	Assignment(s)	Mid-Term	End-Term	
05	05	05	25	60	100

Detailed Syllabus

Module-#	Topics	Hours
Module-1	Introduction to Bitcoin and Blockchain, Basic cryptographic primitives used in Blockchain - Secure, Collison-resistant hash functions, Merkle Tree, Digital Signature, Public Key Cryptosystems, Zero-knowledge Proof Systems.	**9 Hours**
Module-2	Bitcoin blockchain, The challenges and solutions, Proof of work, Proof of stake, Alternatives to Bitcoin consensus, Byzantine models of fault tolerance, Bitcoin scripting language and their use.	**8 Hours**
Module-3	Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts	**9 Hours**
Module-4	Hyperledger Fabric, the Plug-and-Play Platform and mechanisms in permissioned blockchain.	**8 Hours**
Module-5	Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, Attacks on Blockchains - such as Sybil attacks, selfish mining, 51% attacks and prevention (Algorand and Sharding based consensus algorithms).	**8 Hours**
	Total	**42 Hours**

Text Books:

T1. S. Shukla, M. Dhawan, S. Sharma, and S. Venkatesan, ***Blockchain Technology: Cryptocurrency and Applications***, 1st Edition, Oxford University Press, 2019.

T2. J. Thompson, ***Blockchain: The Blockchain for Beginners Guide to Blockchain Technology and Leveraging Blockchain Programming***, Create Space Independent Publishing Platform, 2017.

Reference Books:

R1. W. Stallings, ***Cryptography and Network Security: Principles and Practice***, 6th Edition, Pearson, 2014.

R2. A. J. Menezes, P. C. van Oorschot, and S. A. Vanstone, ***Handbook of Applied Cryptography***, CRC press, 1996.

P.T.O

Online Resources:

1. https://nptel.ac.in/courses/106104220: by Prof. S. Shukla, IIT Kanpur
2. https://nptel.ac.in/courses/106105184: by Prof. S. Chakraborty and P. Jayachandran, IIT Kharagpur
3. https://blockchain.cse.iitk.ac.in/slides-NPTEL-BlockchainTechnologyApplications.pdf
4. https://nvlpubs.nist.gov/nistpubs/ir/2018/nist.ir.8202.pdf
5. https://www.cryptool.org/en/

Course Outcomes: *At the end of this course, the students will be able to:*

CO1	Explain the basics of Bitcoin, Blockchain and Crypto primitives used for their realization.
CO2	Analyze the performance of various consensus protocols used in Bitcoin and Blockchain networks.
CO3	Develop smart contracts by using Ethereum decentralized open source blockchain.
CO4	Describe the basics of Hyperledger fabrics for developing blockchain-based distributed ledgers.
CO5	Analyze security attacks on Blockchain and prevention methodologies.

Program Outcomes Relevant to the Course:

PO1	Develop an understanding of the theoretical foundations and the limits of computing.
PO2	Apply existing models, techniques, algorithms, data structures, etc. for efficiently solving problems.
PO3	Design, develop and evaluate new computer based systems for novel applications which meet the desired needs of industry and society.
PO4	Develop understanding and insight of advanced computing techniques and use of advanced tools.
PO5	Explore ideas and undertake original research at the cutting edge of computer science and its related areas.
PO7	Understand the impact of IT related solutions in an economic, social and environment context.

Mapping of COs to POs and PSOs (1: Low, 2: Medium, 3: High)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3
CO1	2	2	2	1	2		2				2	2	2
CO2	2	2	3	2	2		1				2	2	3
CO3	1	2	3	3	2		2				2	3	3
CO4	1	2	3	3	2		2				2	2	2
CO5	1	1	1	2	1		2				2	3	3

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