Structure of Post Graduate

(ME Computer Science and Engineering)

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

THAPAR INSTITUTE OF ENGINEERING & TECHNIOLOGY
(DEEMED TO BE UNIVERSITY)

PATIALA, PUNJAB, INDIA

COURSE SCHEME & SYLLABUS

(2021)

M.E. (COMPUTER SCIENCE & ENGINEERING)

ME- COMPUTER SCIENCE AND ENGINEERING (2022)

SEMESTER I						
S. NO.	**CODE**	**TITLE**	**L**	**T**	**P**	**Cr**
1	PCS112	Applied Statistical Methods	3	0	2	4
2	PCS108	Advanced Data Structures	3	0	2	4
3	PCS111	Software Project Management	3	0	2	4
4	PCS216	Advanced Computer Architecture	3	0	0	3
5	PCS110	Data Science Foundations	3	0	2	4
6	PHU004	Research Methodology, Ethics and IPR	2	0	0	2
		TOTAL	**17**	**0**	**8**	**21**
SEMESTER II						
1	PMA112	Linear Algebra and Random Processes	3	0	0	3
2	PCS206	Machine Learning	3	0	2	4
3	PCS109	Advanced Algorithms	3	0	2	4
4	PIS105	Secure Coding	3	0	2	4
5		ELECTIVE-I	3	0	2	4
6		ELECTIVE-II	3	0	2	4
		TOTAL	**15**	**0**	**10**	**23**
ELECTIVE I						
1	PCS221	Cloud Infrastructure and Services	3	0	2	4
2	PCS224	Natural Language Processing	3	0	2	4
3	PCS212	Computer and Network Security	3	0	2	4
4	PCS217	Continuous Delivery and DevOps	3	0	2	4
ELECTIVE II						
1	PCS252	GPU Computing	3	0	2	4
2	PCS254	Human Centered Computing	3	0	2	4
3	PCS210	Block Chain Technologies	3	0	2	4
4	PCS253	Quantum Computing	3	0	2	4
SEMESTER III						
1		DISSERTATION/INTERNSHIP Interim Report	-	-	-	4
2	PCS391	Seminar	-	-	-	4
		TOTAL				**8**
SEMESTER IV						
1	PCS392	PROJECT SEMESTER / DISSERTATION	-	-	-	16
		TOTAL	**-**	**-**	**-**	**16**
		GRAND TOTAL - FOUR SEMESTER CREDITS				**68**

PCS112 Applied Statistical Methods

L	T	P	Cr
3	0	2	4

Course Objective: The course aims to introduce to the students, fundamental principles as well as advanced topics in statistics and sampling techniques. This course underscores the importance of statistical methods to perform scientific and engineering research.

Review of basic probability and statistical principles: Axioms of probability, conditional probability, Bayes' rule, Conditional probability distributions, conditional expectations, law of total probability and law of total expectation, introduction to Bernoulli, binomial, Poisson, geometric, Normal, exponential, distributions, joint and marginal distributions, central limit theorem, probability distribution of functions of random variables.

Hypothesis tests: Introduction to sampling distributions (standard Normal, chi-square, F and t distributions) and their properties, introduction to hypothesis tests (difference between one tailed and two tailed tests), level of significance of test and power of test, two sample test for means using t-distribution.

Analysis of variance: One Way ANOVA, two-way ANOVA with examples.

Time Series Analysis: Autoregressive models: AR(1), AR(p), moving average models: MA(1), MA(q), autoregressive moving average models: ARMA(p,q).

Multivariate Data Analysis and regression: Introduction to linear regression with trends and least squares estimate, definition of Covariance matrix and its application in engineering problems using Principal Component Analysis.

Markov Chains: Introduction to discrete Markov chains in finite state space, multi-step state transition probabilities, stationary (limiting distributions), Chapman-Kolmogorov equations, hitting probabilities, return and exit time distributions for discrete Markov chains, classification of states, detailed balance.

Laboratory Work: Each laboratory experiment will consist of numerical exercises on one of the above topics. Laboratory experiments will be performed using Matlab/SPSS.

Course Learning Outcomes (CLO): Upon the completion of this course, the students will able to:

1. compute probabilities of composite events along with an understanding of random variables and distributions.
2. obtain foundational understanding of discrete Markov processes.
3. make statistical inferences using principles of hypothesis tests and ANOVA.
4. perform analysis of time series data with different time series models.

5. perform multivariate data analysis using Principal Component Analysis and linear regression.

Recommended Books:

1. Medhi, J., Stochastic Processes, New Age International (2005)
2. Paul L. Meyer, Introductory probability and statistical applications, Addison-Wesley Publishing Company, 1970
3. Durrett, R., Essentials of Stochastic Processes, Springer (2016).
4. Ross, Sheldon, Stochastic Processes, John Wiley and Sons (1996).
5. Hogg, R., McKean, J. and Craig, A. Introduction to Mathematical Statistics, Pearson (2013).
6. Hamilton, James, Time Series Analysis, Princeton University Press (2012).

PCS108 ADVANCED DATA STRUCTURES				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4**

Course Objective: To learn the advanced concepts of data structure and their implementation. The course has the main ingredients required for a computer science graduate and has all the necessary topics for assessment of data structures.

Introduction: Overview of various linear and non-linear data structures.

Complexity Analysis: Introduction to asymptotic complexity, Complexity of recursive algorithms, Amortized complexity, Complexity analysis of various sorting and searching techniques, Sorting in linear time.

Tree Structures: AVL Trees, Red-Black Trees, Splay Trees, B-trees, B+ Trees, Fibonacci heaps, Data Structures for Disjoint Sets, Augmented Data Structures, Self-Adjusting Data Structures, Temporal data structures, Succinct data structures, Dictionaries and cuckoo hashing.

Data Structures for Graphs and Related Algorithms: Representation, Type of graphs, Paths and circuits:, Euler graphs, Hamiltonian paths and circuits, Cut-sets, Connectivity and separability, Planar graphs, Isomorphism, Graph colouring, Covering and partitioning, Depth- and breadth-first traversals, Minimum spanning tree: Prim's and Kruskal's algorithms, Shortest-path Algorithms: Dijkstra's and Floyd's algorithm, Topological sort, Max flow: Ford-Fulkerson algorithm, Max flow-min cut.

Laboratory Work: To Implement the data structures and related algorithms given above in a high level programming language.

Recommended Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, The MIT Press.
2. Y. Langsam, M. J. Augenstein, and A. O. Tenenbaum, Data Structures Using C and C++, Pearson Education India.
3. Peter Brass, Advanced Data Structures, Cambridge University Press.
4. J. Kleinberg and E. Tardos, Algorithm Design, Pearson Education India.
5. E. Horowitz, S Sahni, & S. Rajasekaran, Computer Algorithms, Computer Science Press.

Course Learning Outcomes (CLOs): After the completion of this course the student will be able to:

CLO1	Analyse the algorithms associated with advanced data structures.
CLO2	Implement basic data structures and analyse them to solve fundamental problems.
CLO3	Implement different tree data structures and differentiate themwith respect to their applications.
CLO4	Identify properties of graphs and employ them to model a variety of real-world problems.

PCS111 SOFTWARE PROJECT MANAGEMENT				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4.0**

Course Objective: It gives an in depth knowledge of software project management and project planning. It also covers the Step Wise framework in project planning

Project Planning: Characteristics of a software project, Software scope and feasibility, resources, the SPM plan.

Software Project Estimation: Size/scope estimation, Decomposition techniques, WBS. Effort estimation: Sizing, Function point, LOC, FP vs LOC. Schedule estimation: GANTT Charts, Activity networks, PERT/CPM networks. Cost estimation: Models: COCOMO I, COCOMO II.

Quality Planning: Quality control, Quality assurance, Formal Technical Reviews, The SQA Plan, ISO and CMM standards.

Risk Management: Reactive vs proactive Risk strategies, Risk projection, Risk Refinement, Risk Monitoring, Monitoring and management, RMMM plan.

Measurement and Tracking Planning: Earned Value Analysis.

Team Management: Team structures: hierarchical, Egoless, chief programmer, mixed; Team software Process; Resource leveling, Building a team: Skill sets.

Configuration Management: Baselines, Configurable items, SCM repository, SCM process, version control change control, configuration audit**.**

Project Monitoring and Control: Audits and Reviews.

Laboratory Work: Implementation of software project management concepts using tools like MS Project, Rational Suite (RequisitePro, Purify, etc.), Advanced Cost Estimation Models.

Recommended Books

1. Software Project Management, Bob Hughes and Mike Cotterell, Tata McGraw Hill 5th edition, 2009
2. A practitioner's Guide to Software Engineering, Roger Pressman, Tata McGraw Hill 2014 8thedition
3. Head First PMP: A Brain Friendly Guide To Passing The Project Management Professional Exam,2013

PCS216 ADVANCED COMPUTER ARCHITECTURE

L	T	P	Cr
3	0	2	4.0

Course Objectives: To learn the fundamental aspects of computer architecture design and analysis, with a focus on processor design, pipelining, superscalar, out-of-order execution, caches (memory hierarchies), virtual memory, storage systems, and simulation technique

Introduction To Parallel Processing: Instruction set architecture, RISC-CISC, single cycle processors, hardwired and micro-coded FSM processors, Parallelism in uniprocessor system, uniprocessor architecture, balancing of sub system bandwidth, multiprogramming and time sharing, parallel computer structures, pipeline computers, array computers, multiprocessor systems, dataflow computer concept, architectural classification scheme: multiplicity of instruction-data streams, parallelism versus pipelining, parallel processing applications, productive modeling simulation, engineering design and automation.

Principles of Pipelining and Vector Processing: Pipelining- an overlapped parallelism, multi-core processors, clock period, efficiency, throughput, classification of pipeline processors, general pipeline and reservation tables, detecting and resolving structural, data, control and name hazards; analyzing processor performance, pipeline efficiency, linear pipelining; Instruction level parallelism and instruction pipelines

Principles of Designing Pipeline Processors: Effect of branching, data buffering and bussing structures, internal forwarding and register tagging, job sequencing and collision prevention, reservation and latency analysis, collision free scheduling, state diagram, greedy cycle, pipeline schedule optimization, Arithmetic pipelines; Pipeline control methods; and pipeline chaining, Loop unrolling, software pipelining and trace scheduling techniques for exposing instruction level parallelism, Dynamic scheduling algorithms, exploiting ILP using static scheduling and dynamic scheduling, hardware based speculation, multiple issues, and speculation

Structure And Algorithm for Array Processors: SIMD array processor, SIMD computer organization, inter –PE communication, SIMD interconnection network, static versus dynamic networks, cube interconnection network, shuffle-exchange omega networks, parallel algorithms and SIMD matrix multiplication, Vector processing characteristics and requirements, pipelined vector processing, vectorization methods, examples of vector processing, Array processing,communication between PEs, SIMD interconnection networks, algorithms for array processing, Data and control parallelism, concurrency, scalability, speedup and Amdahl's law, PRAM model of parallel computation

Multiprocessor Architecture And Scheduling: Functional structure, loosely coupled and tightly coupled multiprocessor, deterministic scheduling strategy, deterministic scheduling model, control flow versus data flow computer, data flow graphs and languages, memory technology; memory addressing modes, direct-mapped, associative cache; write through and write-back caches; single-cycle, pipelined cache; analyzing memory performance, memory Hierarchy, Cache design issues, Virtual memory addressing, memory protection mechanisms, Multiprocessor memory architecture, Multi Core Architectures, Multiprocessors and multi-computers; Processor organizations: mesh, binary tree, hypercube; Shared memory and message passing systems; Mapping and Scheduling: Embedding of task graphs in processor graphs, dilation and loading, load balancing, models for static and dynamic scheduling, Using MPI and Open MP

Recommended Books

1. Kai Hwang, Computer Architecture, TMH
2. Richard Y. Kain, Advanced computer architecture: a systems design, PHI

3. J.L. Hennessy, and D.A. Patterson, Computer Architecture: A quantitative approach, Morgan Kaufman Publication (2012)

4. Quinn, "Parallel Programming in C with MPI and Open MP", TMH

Course Learning Outcomes (CLOs)

CLO 1	Understand different processor architectures, system-level design processes, components and operation of a memory hierarchy
CLO 2	Get an insight into how applications and performance issues influence a range of design choices of computer-based systems
CLO 3	**Develop system's programming skills in the context of computer sy**stem design and organization
CLO 4	Able to understand the principles of I/O in computer systems, including viable mechanisms for I/O and secondary storage organization

PCS110 Data Science Foundations

L	T	P
3	0	2

Course Objective: The course on Data Science aims to deliver in-depth knowledge of various data science techniques.

Introduction to data science: Overview of Data Science, Types of data- Record, Temporal, Spatial-Temporal, Graph, Unstructured, semi and structured data, Raw and Processed data, Data Analysis- Data collection, integration, cleansing, extraction, modeling, prediction, visualization, privacy and security, Data Wrangling, Business Analytics, Business Intelligence, Applications of data sciences, Preparation of data for machine learning models.

Basics of Python programming for data science: Data Types, Data Structures- List, Tuple, Dictionaries, Flow Control, Functions, Overview of Python libraries in context to data science- Scientific computing with Python (SciPy), Numpy arrays, Keras, Tensorflow, Matplotlib, Pandas, Use of Tableau for plotting various charts for data visualization.

Association Rule Mining: Introduction, Association rules, Support and confidence, Itemsets, Frequent itemsets, Closed and maximal Itemsets, Association rule mining methods- Naïve, Apriori, Direct Hashing & Pruning (DHP), Dynamic Itemset Counting, FP- Growth, Performance evaluation of algorithms.

Data Analysis and Visualisation: Getting to know your data, Exploratory Data Analysis, Data Analysis Pipeline: Data pre-processing- Attribute values, Attribute transformation, Sampling, Dimensionality Reduction-PCA, Eigenfaces, Multidimensional Scaling, Non-linear Methods, Graph-based Semi-supervised Learning, Representation Learning Feature subset selection, Distance and Similarity calculation. Visualization- Traditional Visualization, Multivariate Data Visualization, Text Data Visualization, Network Data Visualization, Temporal Data Visualization, and visualization Case Studies, Data visualization in Python using Matplotlib, Visualization, Histograms, Binning Visualization, organizing data and designing dashboards using Tableau.

Big Data Analytics: Introduction to Big Data, Elements of Big Data, Big Data Analytics, Hadoop Echo System, Data Ingestion, MapReduce & Sqoop, Basics of Impala and Hive, Apache Flume and HBase, Apache Pig, Basics of Apache Spark, Spark SQL, Graph databases (Neo4J), NoSQL Databases (MongoDB).

Course Learning Outcomes (CLO):

On completion of this course, the students will be able to:

i) Gain fundamental knowledge of various key concepts of data science and business analytics.

ii) Demonstrate the use of various libraries of python and R to solve real-world problems.

iii) Implement various association rule mining techniques for market-based analysis.

iv) Design and analyze various visualization plots using data analytics and visualization techniques.

v) Understand how Big Data can be analysed to extract knowledge.

Text Books

1) "Joel Grus, Data Science from Scratch: First Principles with Python" 2nd edition, O'Reilly Media.
2) "J.S.Saltz, J.M. Stanton, An Introduction to Data Science", SAGE publications.
3) "Jake VanderPlas, Python Data Science Handbook Essential Tools for Working with Data", O Reilly.

Reference Books

1) "Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R", CRC Press, Taylor & Francis group.
2) "Nina Zumel, John Mount, Practical Data Science with R", Manning Publications, 2014.
3) "F. Provost, T. Fawcett, Data Science for Business", O'Reilly Media, 2013.
4) "Kevin P. Murphy, Machine Learning: A probabilistic perspective", The MIT Press, 2012.
5) "Hadley Wickham, Garrett Grolemund, R for Data Science: Import, Tidy, Transform, Visualize, and Model Data", O'Reilly Media.

PHU004: RESEARCH METHODOLOGY, ETHICS AND IPR

L	T	P	Cr
2	0	0	2

Course Objectives:

The course aims to:

- equip the students to analyse research related information.
- sensitize the students to ethical research practices.
- equip them to write technical reports and research paper.
- equip them with the process of patent filing
- create awareness about the consequences of IPR Infringement

Unit 1: Meaning of Research Problem, Sources of Research Problem, Criteria and Characteristics of good Research Problem, Errors in selecting a research Problem, scope and objectives of research problem.

Unit 2:Effective Literature studies, approaches and analysis.

Unit 3: Effective Technical Writing, How to write report and Research paper; developing a research proposal.

Unit 4: Non Parametric Tests: When to use a Nonparametric Tests**;** Mann Whitney U Test; Sign Test; Wilcoxon Signed Rank Test andKruskal-Wallis Test.

Unit 5: Ethics: Need for Ethics in Professional Life; Kohlberg's Theory of Moral Development and Its Applicability to Engineers.Professional Ethics: Values in Work Life; Professional Ethics and Ethos; Codes of Conduct.

Research Ethics, Plagiarism, Case Studies on Ethics.

Unit 6: Introduction to IPR: Nature of Intellectual Property Rights: Patents; Designs; Trademarks; Copyright; Trade Secrets; Industrial Design; Geographical Indicators; Integrated Circuits. International Character of IPRs, Role of IPRs in Economic Development.

Patents: Introduction to Patents, Inventions not Patentable, Procedure for grant of Patents,Rights and Obligations of a Patentee; IPR Infringement.

Case studies on IPRs.

Course Outcome

At the end of this course the student will be able to:

- analyse research related Information.
- Indulge in ethical research practices
- equipped to write technical reports and research paper.
- Equipped with the process of patent filing
- possess awareness about consequences of IPR Infringement

Text Books:

1. Geoffrey R. Marczyk. Essentials of Research Design and Methodology, Wiley; 2008.
2. Wayne Goddard, Stuart Melville. Research methodology: An Introduction, Juta, 2004.
3. Thomas, C. George. Research Methodology & Scientific Writing, Ane Books Pvt. Ltd, 2016.
4. Menell, Peter S, Lemley, Mark A, Merges, Robert P. Intellectual Property in the New Technological Age, Vol. I Aspen Law & Business, 2019.
5. Menell, Peter S, Lemley, Mark A, Merges, Robert P. Intellectual Property in the New Technological Age, Vol. II Aspen Law & Business, 2019.
6. Narayanan, P., Intellectual Property Law, Eastern Law House, 2008.

PMA112 Linear Algebra and Random Process

L	T	P	Cr
3	0	0	3.0

Course Objective: The course aims to shape the attitudes of learners regarding the field of linear algebra and random process. Specifically, the course aims to (i) develop maturity in linear algebraic structure that appear in various areas of computer science (ii) motivate students towards an intrinsic interest in statistical thinking (iii) instil the belief that statistics is important for scientific research.

Linear Algebra

Matrices: Matrix multiplication, Transposes, Inverses, Gaussian elimination, factorization $A = L\,U$, rank of matrix.

Vector Spaces: Column ad row spaces, Solving $AX = 0$ and $AX = B$, Linear Independence/Dependence, Basis, Dimension and Linear Transformation.

Orthogonality: Orthogonal Vectors and subspaces, projection, and least squares, Gram – Schmidt orthogonalization.

Determinants: Determinant formula, cofactors, inverses and volume.

Eigenvalues and Eigenvectors: Characteristic polynomial, Diogonalization, Hermitian and Unitary matrices, Spectral theorem, Change of basis.

Positive definite matrices and Singular Value Decomposition, Applications to Optimization problems and Graph Theory.

Random Processes

Basic topics: Event, Probability, Conditional probability, Independence, Product spaces

Random Variables: Distributions, Laws of average, discrete and continuous random variables, random vectors, Monte Carlo simulation.

Discrete Random Variables: Probability mass function, Independence, Expectation, Sums of random variables.

Continuous Random Variables: Probability density function, Independence, Expectation, Conditional expectations, Functions of random variables, Sums of random variables, Multivariate normal distributions.

Recommended Books:

1. Gilbert Strang, Linear algebra and Its Applications, Cengage Learning, Fourth edition, 2006.
2. Kenneth Hoffman and Ray Kunze, Linear algebra, Prentice Hall of India, second edition, 2013
3. W. B. Davenport, Probability and Random Process- an introduction for application scientists and engineers, McGraw Hill, 1970
4. Johnson, R., Miller, I. and Freud's, J., Miller and Freund's Probability and Statistics for Engineers, Pearson Education (2005) 7^{th} Ed.
5. Walpole, Ronald E., Myers, Raymond H., Myers, Sharon L. and, Keying Ye, Probability and Statistics for Engineers and Scientists, Pearson Education (2007) 8^{th}ed.

Course Learning Outcomes (CLO): Upon successful completion of the course, the students will be able to

1. Identify and comprehend linear algebraic structures that appear in computer science.
2. Use linear algebraic methods to perform computational task.
3. Apply properties of eigenvalues and orthogonality to analyse computational problems occurring in various areas of computer science.
4. Understand and apply various concepts of probability theory.
5. Comprehend and apply the properties of random processes in real life problems.

PCS 206 MACHINE LEARNING

L	T	P	Cr
3	0	2	4.0

Course Objectives: This course provides an advanced level of understanding to machine learning and statistical pattern recognition. It offers some of the most cost-effective approaches to automated knowledge acquisition in emerging data-rich disciplines and focuses on the theoretical understanding of these methods, as well as their computational implications.

Introduction: Basic concepts, Designing a learning system, Issues in machine learning. Types of machine learning: Learning associations, Supervised learning, Unsupervised learning, Reinforcement learning, Model Evaluation Parameters, Feature Selection and Extraction. Linear Regression, Multi Regression, Gradient Descent, SVM.

Clustering: K-Means, k-Medoids, Agglomerative versus Divisive Hierarchical Clustering Distance Measures in Algorithmic Methods, Mean-shift Clustering.

Decision Tree Learning: Decision tree representation, appropriate problems for decision tree learning, Univariate Trees (Classification and Regression), Multivariate Trees, Basic Decision Tree Learning algorithms, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.

Bayesian Learning: Bayes theorem and concept learning, Bayes optimal classifier, Gibbs algorithms, Naive Bayes Classifier, Bayesian belief networks, The EM algorithm.

Artificial Neural Network: Neural network representation, Neural Networks as a paradigm for parallel processing, Linear discrimination, Pairwise separation, Gradient Descent, Logistic discrimination, Perceptron, Training a perceptron, Multilayer perceptron, Back propagation Algorithm. Recurrent Networks.

Genetic Algorithms: Basic concepts, Hypothesis space search, Genetic programming, Models of evolution and learning, Parallelizing Genetic Algorithms.

Laboratory Work: It is concerned with the design, analysis, implementation, and applications of programs that learn from experience. Learning algorithms can also be used to model aspects of human and animal learning.

Recommended Books

1. Mitchell T.M., Machine Learning, McGraw Hill (1997) 2nd ed.
2. Alpaydin E., Introduction to Machine Learning, MIT Press (2010) 2nd ed.
3. Bishop C., Pattern Recognition and Machine Learning, Springer-Verlag (2006) 2nd ed.
4. Michie D., Spiegelhalter D. J., Taylor C. C., Machine Learning, Neural and Statistical Classification. Overseas Press (2009) 1st ed.

COURSE LEARNING OUTCOMES (CLOs)

After the completion of this course the student will be able to:

CLO1	Understand basic principles, techniques, and applications of machine learning modules.
CLO2	Understand and use regression techniques for real time applications
CLO3	Apply decision tree learning, Bayesian learning, Artificial Neural Network and SVM in real world problems.
CLO4	Critically evaluate and compare different learning models and algorithms and be able to adapt or combine some of the key elements of existing machine learning algorithms to design new algorithms
CLO5	Understand the use of genetic algorithms and genetic programming.

PCS 109 ADVANCED ALGORITHMS

L	T	P	Cr
3	0	2	4

Fundamental Algorithm Paradigm: Divide-and-Conquer, Binary Search, Merge Sort.

Advanced Design and Analysis Techniques: Dynamic Programming, Greedy Approach, Branch-and-Bound, Backtracking, Amortized Analysis, Illustrations of these techniques for Problem-Solving: Bin Packing, Knap Sack, Travelling Salesman Problem.

Numerical algorithms: Integer, Matrix and Polynomial Multiplication, FFT, Extended Euclid's algorithm, Modular Exponentiation, Primality Testing, Cryptographic Computations.

Geometric algorithms: Range searching, Convex Hulls, Segment Intersections, Closest Pairs

String Matching Algorithms: Suffix arrays, Suffix trees, tries, Rabin-Karp, Knuth Morris-Pratt, Boyer Moore algorithm.

Approximation algorithms: Need of approximation algorithms: Introduction to P, NP, NP-Hard and NP-Complete; Deterministic, Non-Deterministic Polynomial time algorithms; Knapsack, TSP, Set Cover, Open Problems.

Randomized algorithms: Introduction, Type of Randomized Algorithms, Quick Sort, Min-Cut, 2-SAT; Game Theoretic Techniques, Random Walks.

Online Algorithms: Introduction, Online Paging Problem, Adversary Models, K-server Problem.

Laboratory Work: Design and implement algorithms for problems given above in a high level programming language.

Recommended Books:

1. Cormen H. T., Leiserson E. C., Rivest L. R., and Stein C., Introduction to Algorithms, MIT Press (2009) 3rd ed.
2. J. Kleinberg and E. Tardos, Algorithm Design, Addison-Wesley.
3. A. V. Aho , J. E. Hopcroft . and J. D. Ullman, The Design and Analysis of Algorithms, Addison-Wesley, 1974.
4. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press.
5. Vijay Vazirani, Approximation Algorithms, Springer.

Course Learning Outcomes (CLOs):

1. Identify the appropriate algorithmic approach to a problem.
2. Compare algorithms, provide justification for selection of specific algorithm and implement the algorithm in a particular context.
3. Use advanced techniques to model a variety of real-world problems to solve and analyze them.
4. Implement advance algorithmic techniques such as String Matching Algorithms, Approximation algorithms etc.

PIS105 SECURE CODING				
L	**T**	**P**	**Cr**	
3	**0**	**2**	**4**	

Course Objective: This course aims to provide an understanding of the various security attacks and knowledge to recognize and remove common coding errors that lead to vulnerabilities. It gives an outline of the techniques for developing a secure application.

Introduction: Security, CIA Triad, Viruses, Trojans, and Worms In a Nutshell, Security Concepts- exploit, threat, vulnerability, risk, attack. Malware Terminology: Rootkits, Trapdoors, Botnets, Key loggers, Honeypots.Active and Passive Security Attacks. IP Spoofing, Tear drop, DoS, DDoS, XSS, SQL injection, Smurf, Man in middle, Format String attack. Types of Security Vulnerabilities- buffer overflows, Invalidated input, race conditions, access-control problems, weaknesses in authentication, authorization, or cryptographic practices. Access Control Problems.

Proactive Security development process: Secure Software Development Cycle (S-SDLC), Security issues while writing SRS, Design phase security, Development Phase, Test Phase, Maintenance Phase, Writing Secure Code – Best Practices SD3 (Secure by design, default and deployment), Security principles and Secure Product Development Timeline.

Threat modelling process and its benefits: Identifying the Threats by Using Attack Trees and rating threats using DREAD, Risk Mitigation Techniques and Security Best Practices. Security techniques, authentication, authorization. Defence in Depth and Principle of Least Privilege.

Secure Coding Techniques: Protection against DoS attacks, Application Failure Attacks, CPU Starvation Attacks, Insecure Coding Practices In Java Technology. ARP Spoofing and its countermeasures. Buffer Overrun- Stack overrun, Heap Overrun, Array Indexing Errors, Format String Bugs. Security Issues in C Language: String Handling, Avoiding Integer Overflows and Underflows and Type Conversion Issues- Memory Management Issues, Code Injection Attacks, Canary based countermeasures using Stack Guard and Propolice. Socket Security, Avoiding Server Hijacking, Securing RPC, ActiveX and DCOM

Database and Web-specific issues: SQL Injection Techniques and Remedies, Race conditions, Time of Check Versus Time of Use and its protection mechanisms. Validating Input and Interprocess Communication, Securing Signal Handlers and File Operations. XSS scripting attack and its types – Persistent and Non persistent attack XSS Countermeasures and Bypassing the XSS Filters.

Testing Secure Applications: Security code overview, secure software installation. The Role of the Security Tester, Building the Security Test Plan. Testing HTTP-Based Applications, Testing File-Based Applications, Testing Clients with Rogue Servers

Laboratory work: consists of using network monitoring tools, implementing different types of attacks and some protection schemes.

Recommended Books

1. Michael Howard and David LeBlanc, Writing Secure Code, Microsoft Press, (2004)
2. Jason Deckard, Buffer Overflow Attacks: Detect, Exploit, Prevent by Syngress, (2005)
3. Frank Swiderski and Window Snyder, Threat Modelling, Microsoft Professional, (2004)

Course Learning Outcomes (CLOs)

CLO1	To implement security as a culture and show mistakes that make applications vulnerable to attacks.
CLO2	To analyze various attacks like DoS, buffer overflow, web specific, database specific, web-spoofing attacks.
CLO3	To demonstrate skills needed to deal with common programming errors that lead to most security problems and to learn how to develop secure applications.
CLO4	To identify the nature of the threats to software and incorporate secure coding practices throughout the planning and development of the product.
CLO5	To properly handle application faults, implement secure authentication, authorization and data validation controls used to prevent common vulnerabilities.

PCS221 CLOUD INFRASTRUCTURE AND SERVICES

L	T	P	Cr
3	0	2	4

Course Objective: To learn the advanced concepts of cloud infrastructure and services and its implementation for assessment of understanding the course by the students.

Introduction: Cloud Computing, History and evolution, Overview of Types of Computing: Cluster, Grid, Utility and Autonomic Computing, Applications of cloud computing for various industries, economics and benefits of cloud computing.

Cloud Computing Architecture: Cloud Architecture, Types of Clouds: Public, Private & Hybrid Clouds, Cloud based services: Iaas, PaaS and SaaS.

Cloud Computing Issues and Challenges: Security, Elasticity, Resource management and scheduling, QoS (Quality of Service) and Resource Allocation, Cost Management, Big Data.

Data Center and Warehousing : Classic Data Center, Warehousing, Virtualized Data Center (Compute, Storage, Networking and Application), Design Principles.

Cloud Implementations and Environments: Amazon Web Services, The Elastic Compute Cloud (EC2), The Simple Storage Service (S3), The Simple Queuing Services (SQS), Google AppEngine - PaaS, Windows Azure, Aneka, A Comparison of Cloud Computing Platforms.

Virtualization: Virtualization, Advantages and Disadvantages, Types of Virtualization: Resource Virtualization i.e. Server, Storage and Network virtualization, Migration of processes, para-virtualization, full-virtualization, Cloning, Snapshot and Template,VMware cloud – IaaS.

Cloud based Data Storage: Introduction to Hadoop and Map Reduce for Simplified data processing on Large clusters, Distributed File system, Data Replication, Shared access to data stores, introduction to Python, Design of data applications based on Map Reduce, Task Partitioning, Data partitioning, Data Synchronization.

Laboratory Work: To implement Cloud, Apache and Hadoop framework and related services. To understand various concepts practically about virtualization, data storage. To implement few algorithms with the help of MapReduce and some high level language. To create a cloud instance, add storage and set up a web server on the instance, review and deletion of the instance.

Recommended Books:

1. *Raj Kumar Buyya, James Broberg, Andrezei M.Goscinski, Cloud Computing: Principles and paradigms (2011)*
2. *Michael Miller, Cloud Computing, Que Publishing (2008).*
3. *Cloud Computing: A practical Approach Anthony Velte, Toby Velte and RobertElsenpeter by Tata McGrawHill*
4. *Judith Hurwitz, Robin Bllor, Marcia Kaufman, Fern Halper, Cloud Computing for dummies (2009).*
5. *T. white, Hadoop: The Definitive Guide, O' Reilly Media (2012), 3rd ed.*

Course Learning Outcomes (CLOs)

CLO1	Understand the existing hosting platforms and computing paradigms currently being used in industry and academia.
CLO2	Comprehend data centre needs, its virtualization techniques and types of clouds.
CLO3	Apply virtualization in Amazon Web Services, Azure, Aneka etc.
CLO4	Learn to use cloud based data storage.
CLO5	Learn Hadoop file system and MapReduce Programing.

PCS224 NATURAL LANGUAGE PROCESSING				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4**

Course Objectives: To understand the advanced concepts of Natural Language Processing and to be able to apply the various concepts of NLP in other application areas.

Introduction: Origin of Natural Language Processing (NLP), Challenges of NLP, NLP Applications, Processing Indian Languages.

Words and Word Forms: Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields, Scope Ambiguity and Attachment Ambiguity resolution.

Machine Translation: Need of MT, Problems of Machine Translation, MT Approaches, Direct Machine Translations, Rule-Based Machine Translation, Knowledge Based MT System, Statistical Machine Translation, UNL Based Machine Translation, Translation involving Indian Languages.

Meaning: Lexical Knowledge Networks, WorldNet Theory; Indian Language Word Nets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors.

Speech Recognition: Signal processing and analysis method, Articulation and acoustics, Phonology and phonetic transcription, Word Boundary Detection; Argmax based computations; HMM and Speech Recognition.

Other Applications: Sentiment Analysis; Text Entailment; Question Answering in Multilingual Setting; NLP in Information Retrieval, Cross-Lingual IR.

Laboratory Work: To implement Natural language concepts and computational linguistics concepts using popular tools and technologies. To implement key algorithms used in Natural Language Processing.

Recommended Books:

1. *Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press (2008).*
2. *Allen J., Natural Language understanding, Benjamin/Cunnings, (1987).*
3. *Jensen K., Heidorn G.E., Richardson S.D., Natural Language Processing: The PLNLP Approach, Springer (2013).*
4. *Roach P., Phonetics, Oxford University Press (2012).*

Course Learning Outcomes (CLOs)

CLO1	To comprehend the concept of Natural Language Processing (NLP), its challenges and applications.
CLO2	To process words and word forms of the language by considering its morphology, paradigms and named entities.
CLO3	To demonstrate and implement the use of machine translation by using rule-based MT, Knowledge Based MT and Statistical Machine Translation etc.
CLO4	To comprehend the concepts of WorldNet, Semantic Roles and Word Sense Disambiguation
CLO5	To demonstrate the use of NLP in speech recognition and other emerging applications like Sentiment Analysis, Information Retrieval etc.

PCS212 COMPUTER AND NETWORK SECURITY

L	T	P	Cr
3	0	2	4

Course Objectives: This course is designed to impart a critical theoretical and detailed practical knowledge of a range of computer network security technologies as well as network security tools and services related to ethical hacking.

Introduction: Security, Functionality and ease of use Triangle, Essential Terminology, Elements of Security, Difference between Penetration Testing and Ethical Hacking, Deliverables ethics and legality, Computer Crimes and Implications.

Reconnaissance: Information Gathering Methodology, Locate the Network Range, Active and Passive reconnaissance

Scanning: Scanning, Elaboration phase, active scanning, scanning tools NMAP, hping2. Enumeration, DNS Zone transfer. Detecting live systems on the network, Discovering services running /listening on target systems, Understandingport scanning techniques, Identifying TCP and UDP services running on the network, Active and passive fingerprinting

Trojans and Backdoors: Effect on Business, Trojan, Overt and Covert Channels, Working of Trojans, Different Types of Trojans, Different ways a Trojan can get into a system, Indications of a Trojan Attack, Some famous Trojans and ports used by them

Sniffers: Definition of sniffing, Sniffer working, Passive Sniffing, Active Sniffing, Ethreal tool, Man-in-the-Middle Attacks, Spoofing and Sniffing Attacks, ARP Poisoning and countermeasures. Denial of Service:Goal of DoS (Denial of Service), Impact and Modes of Attack.

Social Engineering: Social Engineering, Art of Manipulation, Human Weakness, Common Types of Social Engineering, Human Based Impersonation, Example of Social Engineering, Computer Based Social Engineering, Reverse Social Engineering, Policies and Procedures, Security Policies-checklist

Session Hijacking: Understanding Session Hijacking, Spoofing vs Hijacking, Steps in Session Hijacking, Types of Session Hijacking, TCP Concepts 3 Way and shake, Sequence numbers

Ethical Hacking: System Hacking and Hacking Wireless Networks: Aspect of remote password guessing, Role of eavesdropping, Various methods of password cracking, Keystroke Loggers, Understanding Sniffers, Comprehending Active and Passive Sniffing, ARP Spoofing and Redirection, DNS and IP Sniffing, HTTPS Sniffing. Introduction to 802.11, Role of WEP, Cracking WEP Keys, Sniffing Traffic, Wireless DOS attacks, WLAN Scanners, WLAN Sniffers, Hacking Tools, Securing Wireless Networks.

Laboratory work: deals with launching different types of attacks and creating a network blueprint of an organization.

Recommended Books

1. *Eric Core, Hackers Beware, EC-Council Press, (2003)*
2. *William Stallings, Network Security Essentials, Prentice Hall, (2013)*
3. *William R. Cheswick and Steven M. Bellovin, Firewalls and Internet Security, Addison-Wesley Professional, (2003.)*
4. W. Stallings, Cryptography and Network Security, Prentice Hall (2010)

Course Learning Outcomes (CLOs)

CLO1	Demonstrate knowledge of various vulnerabilities in network applications.
CLO2	Practice awareness of various malicious content and guiding ways for protection against the same.
CLO3	Demonstrate knowledge of various forms of attacks.
CLO4	Recall judicious and ethical use of various tools.
CLO5	Expertise in the techniques of system hacking and hacking over a wireless network.

PCS217 Continuous Delivery and DevOps

L	T	P	Cr
3	0	2	4.0

Course Objectives: This course makes student learn the fundamental principles and practices associated with DevOPs. To apply the principles and practices of DevOps and automation on a project of interest and relevance to the student.

Introduction to DevOps: History of DevOps, DevOps Ecosystem, DevOps Objectives, DevOps Market Trends, Infrastructure As A Code, IaaS Overview, Paas Overview, DevOps on the Cloud, DevOps Production Model, Tool pipelining

DevOps and Automation: Version Control, Continuous Integration, Continuous Testing, Configuration Management, Continuous Deployment, Containerization, Continuous Monitoring, Tool pipelining

Version Control: Introduction to version control, Introduction toGit, importance of Git for an organization, Common commands in Git, Working with Remote Repositories, Branching and Merging in Git, Git workflows, Git cheat sheet.

Continuous Integration: Introduction to Jenkins and its Architecture, Jenkins Management, Build Setup, Git and Jenkins Integration

Continuous Testing: Agile Testing Techniques, Test-Driven Development (TDD), Behaviour Driven Development (BDD), Acceptance Test Driven Development (ATDD) Life Cycle, User Acceptance Test, Definition of Done (DoD), fit test, early testing and traditional testing techniques, Introduction to Selenium,Selenium – Webdriver, X-Path, Creating Test Cases in Selenium WebDriver (Waits), Handling different controls on Webpage

.

Containerization: Benefits and use cases for containerized environments, Shipping Transportation Challenges, Introduction to Docker, Understanding images and containers, Introduction to Container, Container Life Cycle, Sharing and Copying, Base Image, Docker File, Working with containers, Publishing Image on Docker Hub, Install Docker on a local machine, Define a container environment using a Dockerfile, Store and share a docker Deployment, Container Deployment, Container orchestration, Kubernetes and container clusters, Continuous Delivery (CD) and Continuous Integration (CI) with AWS CodePipeline and AWS CodeBuild

Self Learning Content: Linux Commands,Introduction to Cloud,IaaC, IaaS, PaaS and SaaS, AWS,Virtualisation, REST API, SQL, Introduction to SQLAlchemy and Postgresql,HTTP and Flask Basics, ELK, Enabling tools for DevOps: Software configuration tools, Orchestration tools and Automated QA tools, Chef, Puppet, Docker,Vagrant, and Selenium, Maven, Ansible, Nagios

Laboratory Work: Exploring and installing the DevOps enabling tools. Students will be given small project deploying a Flask-based web application to the cloud using Docker and Kubernetes

CLOs

1. Comprehend the basic concepts of DevOps and automation.
2. Apply version control using Git for remote repositories
3. Apply agile testing techniques
4. Continuous Delivery (CD) and Continuous Integration (CI) with AWS CodePipeline and AWS CodeBuild

Recommended Books

1. Sharma S., The DevOps Adoption Playbook: A Guide to Adopting DevOps in a Multi-Speed IT Enterprise Wiley; 1st Ed., 2017
2. Relan K, Building REST APIs with Flask: Create Python Web Services with MySQL, Apress,1st Ed., 2019

PCS252 GPU COMPUTING

L	T	P	Cr
3	0	2	4.0

Course Objective: To study architecture and capabilities of modern GPUs and learn programming techniques for the GPU such as CUDA programming model.

Introduction : Heterogeneous Parallel Computing, Architecture of a Modern GPU, Speeding Up Real Applications, Parallel Programming Languages and Models.

History of GPU Computing : Evolution of Graphics Pipelines, The Era of Fixed-Function Graphics Pipelines, Evolution of Programmable Real-Time Graphics, Unified Graphics and Computing Processors, GPGPU, Scalable GPUs, Recent Developments, Future Trends.

Introduction to Data Parallelism and CUDA C : Data Parallelism, CUDA Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading.

Data-Parallel Execution Model : CUDA Thread Organization, Mapping Threads to Multidimensional Data, Matrix-Matrix Multiplication—A More Complex Kernel, Synchronization and Transparent Scalability, Assigning Resources to Blocks, Thread Scheduling and Latency Tolerance.

CUDA Memories: Importance of Memory Access Efficiency, CUDA Device Memory Types, A Tiled Matrix – À Matrix Multiplication Kernel, Memory as a Limiting Factor to Parallelism.

An Introduction to OpenCL : Data Parallelism Model, Device Architecture, Kernel Functions, Device Management and Kernel Launch, Electrostatic Potential Map in OpenCL.

Parallel Programming with OpenACC : OpenACC Versus CUDA C, Execution Model, Memory Model, Basic OpenACC Programs, Parallel Construct, Loop Construct, Kernels Construct, Data Management, Asynchronous Computation and Data Transfer.

Laboratory work: Practice programs using CUDA, OpenCL and OpenACC.

Text Books:

1. J. Sanders and E. Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, nvidia, (2011).
2. David B. Kirk, Wen-mei W. Hwu. Programming Massively Parallel Processors: A Hands-on Approach. Morgan Kaufmann, (2013).

Reference Books:

1. **Wen-mei W. Hwu**, AGPU Computing Gems Emerald Edition (Applications of GPU Computing Series), Morgan Kaufmann, (2011).

Course Learning Outcomes (CLOS):

On completion of this course, the students will be able to:
1. Define terminology commonly used in parallel computing, such as ***efficiency*** and ***speedup***.
2. Describe common GPU architectures and programming models.
3. Implement efficient algorithms for common application kernels, such as matrix multiplication.
4. Given a problem, develop an efficient parallel algorithm to solve it.
5. Given a problem, implement an efficient and correct code to solve it, analyze its performance, and give convincing written and oral presentations explaining your achievements.

PCS254 HUMAN CENTERED COMPUTING				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4**

Course Objective: To learn the foundations of Human Computer Interaction. Be familiar with the design technologies for individuals and persons with disabilities. Be aware of mobile HCI. Learn the guidelines for user interface.

Introduction: Foundation – Human – Computer – Interaction –Paradigms – What is HCI – Components – Cognitive Framework – Perception and Representation – Attention and Memory Constraint – Knowledge and Mental Model – Interface Metaphors – Input – Output

Design & Software Process: Interactive Design basics – process – scenarios – navigation – screen design – Iteration and prototyping. HCI in software process – software life cycle – usability engineering – use case diagram, –Prototyping in practice–design rationale -Issue-based information system (IBIS), Design space analysis, Design rules – principles, standards, guidelines, rules. Evaluation Techniques – Universal Design.

Models and Theories: Task Analysis - Hierarchical Task Analysis, Cognitive models –Socio-Organizational issues and stake holder requirements –Communication and collaboration models-Hypertext, Multimedia and WWW.

Mobile HCI: Mobile Ecosystem: Platforms, Application frameworks- Types of Mobile Applications: Widgets, Applications, Games- Mobile Information Architecture, Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools.

Web Interface Design: Designing Web Interfaces – Drag & Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow. Case Studies.

Applications: Socio –organization issues and stakeholder requirements -Ubiquitous Computing -Context –aware User Interfaces -Hypertext, multimedia and the World Wide Web.

Recommended Books

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, "Human Computer Interaction", 3rd Edition, Pearson Education, 2004
2. Brian Fling, "Mobile Design and Development", First Edition , O"Reilly Media Inc., 2009
3. Bill Scott and Theresa Neil, "Designing Web Interfaces", First Edition, O"Reilly, 2009
4. Julie A. Jacko (Ed.). (2012). Human-Computer Interaction Handbook (3rd Edition). CRC Press. ISBN 1-4398-2943-8
5. Wilbert O. Galitz, The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques, John Wiley & Sons (2007).

COURSE LEARNI NG OUTCOMES (CLOs)

CLO1	To develop good design for human machine interaction system.
CLO2	Analyze the user's need in interaction system
CLO3	To design new interaction model to satisfy all types of customers
CLO4	Evaluate the usability and effectiveness of various products
CLO5	To know how to apply interaction techniques for systems

PCS210 BLOCKCHAIN TECHNOLOGIES

L T P Cr

3 0 2 4

Cryptography: Traditional and Modern Cryptography techniques. Symmetric key cryptography, Asymmetric key cryptography (ECC and RSA), Signatures, hash.

Blockchain definition, shortcomings of current transaction systems, distributed network, difference between blockchain and traditional database, evaluation of blockchain. Core Components of Blockchain Architecture, Bitcoin's block structure, node, Merkle Trees, Shared ledger, Mining, validators.

Consensus and cryptography behind the blockchain:
Bitcoin Blockchain transaction flow. Blockchain need, use cases of blockchain, Types of Blockchain Architecture (public, private, consortium).

How consensus works?Consensus in Bitcoin – I (The Basics, PoW and Beyond, The Miners), Permissioned Blockchain, proof of stake, delegated proof of stake, round robin, PBFT, POET.

Ethereum: Public consortium blockchain:
Introduction of Ethereum, Ethereum account, Ethereum network, Ethereum client, Ethereum gas, Ethereum virtual machine,Ethereum block, header, Ether.

Solidity language: Writing smart contracts: Ethereum development: Preparing smart contract,development tools: remix, geth and mist etc., token standard.

Hyperledger: Private consortium:
Hyperledger Burrow, Hyperledger Sawtooth, Hyperledger fabric, Hyperledger indy, Hyperledger iroha. Hyperledger suitability according to project. Tools in Hyperledger: Caliper, composer, explorer.

Evil Sides of Blockchain and Legal Regulations for Blockchain:
Ransomware, Money Laundering, Cyber Currencies, Cyber Security Exchanges-The 'Dark' Side of Blockchain, Criminal Use of Payment Blockchains, The Role of Financial Regulations for Blockchain, Does Blockchain Need Legal Regulations, Global Digital Assets Regulatory Trends

Laboratory Work: To design and implement algorithms on the above topics. Laboratory experiments will be performed using different blockchain tools: remix, geth and mist etc.

Recommended Books:

- Blockchain by Melanie Swa, O'Reilly, 1 edition (2015).
- Mastering Bitcoin: Unlocking Digital Cryptocurrencies, by Andreas Antonopoulos,O'Reilly, 1 edition (December 20, 2014).
- Blockchain quick reference, by Brenn Hill, Packt Publishing; 1 edition (August 10, 2018),

Course Learning Outcomes (CLOs):

1. Understand the basic concept of modern and traditional cryptography techniques.

2. Comprehend the concept of Blockchain Architecture (public, private, consortium).

3. Demonstrate the Ethereum, Ethereum network, and Bitcoin's block structure.

4. Development of smart contracts: Ethereum development.

5. Demonstrate Hyperledger fabric and Hyperledger suitability for project development.

PCS253 QUANTUM COMPUTING

L	T	P	Cr
3	0	2	4.0

Course objective: This is an advanced Post graduate course on quantum computation. Students will able to learn different quantum algorithms and how quantum computers solve problems faster than classical computer.

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits, basics of quantum mechanics, Measurements in bases other than computational basis. quantum gates Hilbert spaces, Dirac's notation Entanglement, EPR paradox, Bell's inequality, teleportation Postulates of quantum mechanics, super dense coding.

Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits. quantum parallelism,Quantum circuits, universal gates Postulates of QM , Density matrices

Quantum Algorithms : Deutsch's algorithm, BB84 algorithm, B92 algorithm, Three stage quantum cryptography algorithm, compact coding, Fourier sampling, Simon's algorithm, Quantum Fourier transform, Number theoretic preliminaries for factoring, order finding and Hidden subgroup problem Grover search algorithm.

Quantum Information and Modern Quantum Cryptography: RSA Cryptosystem, Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem Classical period finding problem, Shor's factoring algorithm, order finding and periodicity Shor's factoring and discrete logarithm, hidden sub-groups Phase estimation and Kitaev's factoring algorithm, Grover's quantum search algorithm Optimality of Grover's quantum search algorithm.

Classical Information: Shannon's source coding theorem (1), Shannon's source coding theorem (2), Shannon's channel coding theorem Basics of coding - linear codes

Quantum information theory: basics, Graph states and codes, Quantum error correction, fault-tolerant computation.

Laboratory work: To implement Quantum algorithm in any quantum programming language/quantum simulator.

Text Books:

1. Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press.
2. Pittenger A. O., An Introduction to Quantum Computing Algorithms
3. A. Yu Kitaev, A. H. Shen and M. N. Vyalyi (2002). Classical and Quantum Computation, American Mathematical Society.

Recommended Books:

1. Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press.
2. McMahon, David (2008). Quantum Computing Explained. John Wiley & Sons, Inc.

Course Learning Outcomes (CLOs): On completion of this course, students will be able to

CLO1	Knowledge of Performance gain by quantum algorithms over classical algorithms
CLO2	Comprehend the basic concepts for designing quantum algorithms.
CLO3	Acquire the knowledge of Shor's algorithm, Grover's algorithm and comparison with the classical algorithms.
CLO4	Illustrate the concepts of Quantum Error Correction codes.

PCS391 SEMINAR				
	L	**T**	**P**	**Cr**
	0	**0**	**0**	**2**

Course Objectives: This course is designed to help the student obtain skills to discuss or present something within a group. Seminar Course is an outcome of six months of study, exploration, survey and analysis of a particular topic. It is designed to test the skills of the candidate in making a good presentation, Audience Engagement, Communication Skills. It also helps in building lifelong learning as a skill in the candidate.

Course Learning Outcomes (CLOs)

CLO1	Identification of a domain specific scholarly topic
CLO2	Investigate and tabulate details and history about the selected topic
CLO3	Application of the selected topic in domain or real life
CLO4	Technical report writing
CLO5	Demonstrating the communication skills by good presentation and engaging the audience.

Evaluation Scheme:

- Presenting a topic to an audience in a given time with a professionally prepared content.
- Literature Survey/Content: This includes the depth knowledge of the related work done by others related to Seminar Topic
- Viva (answer to the queries)
- Report Writing

MINOR PROJECT

L	T	P	Cr
-	-	-	**6.0**

Course Objectives: This course is designed to encourage design projects where students take what they have learned throughout the course of their ME program and apply it examine a specific idea.

Course Outcomes (CO): After the completion of this course the students will be able to:

1. Investigate and identity the real world problems
2. Design, develop and implement a domain specific design/research problem.
3. Develop acumen for higher education and research.
4. Enhance technical report writing skills.

PCS392 DISSERTATION	
	Cr 16
Course Objectives: This course is designed to help the student obtain research skills which includes a thorough survey of a particular domain, finding a research problem and presenting a methodology to resolve the problem; with adequate experimental results to strengthen the contribution. The students are also given an exposure where they learn to write research papers and presenting the work in the conferences. Students are also supposed to learn about communicating the impact of their work by different tools which includes video, poster and presentation.	

Course Learning Outcomes (CLOs)

CLO1	Design and implementation of identified research problem or industrial projects.
CLO2	Develop acumen for higher education and research.
CLO3	Write technical reports and publish the research work in referred journals, national and international conferences of repute.
CLO4	Foresee how their current and future work will influence/impact the economy, society and the environment.

Evaluation Scheme:

- Subject matter of Presentation
- Literature Review
- Discussion of Results and Inferences drawn
- Presentation Structuring
- Response to Questions
- Usefulness/Contribution to the profession
- Overall Perception
- Reflective Diary
- Publication
- Poster
- Video Presentation