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

(2019)

M.E. (COMPUTER SCIENCE & ENGINEERING)

ME- COMPUTER SCIENCE AND ENGINEERING (2019)

SEMESTER I						
S. NO.	**CODE**	**TITLE**	**L**	**T**	**P**	**Cr**
1	PCL108	Statistical Methods and Analysis	3	0	2	4
2	PCS108	Advanced Data Structures	3	0	2	4
3	PCS109	Advanced Algorithms	3	0	2	4
4	PMA112	Linear Algebra and Random Processes	3	0	0	3
5	PCS106	Machine Learning	3	0	2	4
6	PHU004	Research Methodology, Ethics and IPR	2	0	0	2
		TOTAL	**17**	**0**	**8**	**21**
SEMESTER II						
1	PCS210	Block Chain Technologies	3	0	2	4
2		ELECTIVE-I	3	0	2	4
3		ELECTIVE-II	3	0	2	4
4		ELECTIVE-III	3	0	2	4
5		ELECTIVE-IV	3	0	2	4
		TOTAL	**15**	**0**	**10**	**24**
ELECTIVE I						
1	PCS234	Data Warehouse and Data Mining	3	0	2	4
2	PCS235	Web Search & Information Retrieval	3	0	2	4
3	PCS236	Deep learning	3	0	2	4
4	PCS237	Big Data Analytics	3	0	2	4
ELECTIVE II						
1	PCS208	Recommender System	3	0	2	4
2	PCS224	Natural Language Processing	3	0	2	4
3	PCS221	Cloud Infrastructure and Services	3	0	2	4
4	PCS214	Advanced Computer Architecture	3	0	2	4
ELECTIVEIII						
1	PCS241	Digital Forensics and Ethical Hacking	3	0	2	4
2	PCS242	Steganography & Digital Watermarking	3	0	2	4
3	PCS206	Secure Coding	3	0	2	4
4	PCS205	Network Security and Ethical Hacking	3	0	2	4
ELECTIVEIV						
1	PCS251	Distributed Database	3	0	2	4
2	PCS252	GPU Computing	3	0	2	4
3	PCS253	Quantum Computing	3	0	2	4
4	PCS254	Human Centered Computing	3	0	2	4
SEMESTER III						
1		DISSERTATION/ INTERNSHIP (STARTS)	-	-	-	-
2		Capstone Project	-	-	-	8
		TOTAL				
SEMESTER IV						
1	PCS392	PROJECT SEMESTER / DISSERTATION	-	-	-	16
		TOTAL	**-**	**-**	**-**	**24**
		GRAND TOTAL - FOUR SEMESTER CREDITS				**69**

PCL108 Statistical Methods and Algorithms (for M.tech CSE, Mech., Civil)

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**	**4**	**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 to Basic Data Structures: Importance and need of good data structures, Arrays, Linked lists; Abstract data types and their implementation: Stacks, Queues, Heaps, Priority queues, Sets, Maps, Binary search trees, Hashing; Strategies for choosing the appropriate data structures.

Advanced Data 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.

Internal and External Sorting algorithms: Linear Search, Binary Search, Bubble Sort, Selection Sort, Insertion Sort, Shell Sort, Quick Sort, Heap Sort, Merge Sort, Counting Sort, Radix Sort.

Graphs & Algorithms: Representation, Type of Graphs, Paths and Circuits: Euler Graphs, Hamiltonian Paths & Circuits; Cut-sets, Connectivity and Separability, Planar Graphs, Isomorphism, Graph Coloring, 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.

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

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

Recommended Books:

1. Cormen, Leiserson, Rivest, & Stein, Introduction to Algorithms, The MIT Press (2009), 3rd Edition.
2. Langsam, Augenstein, & Tenenbaum, Data Structures Using C and C++, Pearson Education India (2015), 2nd edition.
3. Tremblay & Sorenson, An Introduction to Data Structures with Application, McGraw Hill Education (2017), 2nd edition.
4. Kleinberg & Tardos, Algorithm Design, Pearson Education India (2013), 1st Edition.
5. Sedgewick & Wayne, Algorithms, Addison-Wesley Professional (2011), 4th Edition.
6. Horowitz, Sahni, & Rajasekaran, Fundamentals of Computer Algorithms, Universities Press (2008), 2nd Edition.

Course Learning Outcomes (CLOs)

CLO1	Implement basic data structures and analyze them to solve fundamental problems.
CLO2	Implement different tree data structures and differentiate among them with respect to their applications.
CLO3	Identify properties of graphs and employ them to model a variety of real-world problems.
CLO4	Demonstrate the usage of several string matching algorithms and associated data structures.
CLO5	Analyse, evaluate and choose appropriate data structure to solve real-world problems.

Student Outcomes (SOs)

A2	Applying basic principles of science towards solving engineering problems.
A3	Applying engineering techniques for solving computing problems.
B1	Identify the constraints, assumptions and models for the problems
B2	Use appropriate methods, tools and techniques for data collection.
E1	Identify engineering problems.
E3	Use analytical and computational methods to obtain solutions.
H1	Aware of environmental and societal impact of engineering solutions.
I2	Recognize the importance of life-long learning.
J1	Comprehend the importance of contemporary issues.
K2	Apply different data structures and algorithmic techniques.

PCS 109 ADVANCED ALGORITHMS

L	T	P
3	0	2

Fundamental Algorithm Paradigms: Divide-and-Conquer, Dynamic Programming, Greedy, Branch-and-Bound, Backtracking; Illustrations of these techniques for Problem-Solving: Bin Packing, Knap Sack, TSP; Amortized Analysis.

Graph Algorithms: Traversal algorithms: Depth First Search (DFS) and Breadth First Search (BFS); Shortest path algorithms, Transitive closure, Minimum Spanning Tree, Topological sorting, Flow Network.

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.

Laboratory Work: To 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. To learn the appropriate algorithmic approach to a problem.
2. Demonstrate the ability to evaluate algorithms, to provide justification for that selection, and to implement the algorithm in a particular context.
3. Employ graphs to model a variety of real-world problems, synthesise tree and graph algorithms and analyze them.
4. Implement advance algorithmic techniques such as String Matching Algorithms, Approximation algorithms etc.

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.

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

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

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) 7th Ed.
5. Walpole, Ronald E., Myers, Raymond H., Myers, Sharon L. and, Keying Ye, Probability and Statistics for Engineers and Scientists, Pearson Education (2007) 8thed.

PCS 106 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: Well-Posed learning problems, Basic concepts, Designing a learning system, Issues in machine learning. Types of machine learning: Learning associations, Supervised learning (Classification and Regression Trees, Support vector machines), Unsupervised learning (Clustering), Instance-based learning (K-nearest Neighbor, Locally weighted regression, Radial Basis Function), Reinforcement learning (Learning Task, Q-learning, Value function approximation, Temporal difference learning).

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, Dynamically modifying network structure.

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

Data Mining Techniques for Analysis: Classification: Decision tree induction, Bayes classification, Rule-based classification, Support Vector Machines, Classification Using Frequent Patterns, k-Nearest-Neighbor, Fuzzy-set approach Classifier, Clustering:K-Means, k-Medoids, Agglomerative versus Divisive Hierarchical Clustering Distance Measures in Algorithmic Methods, Mean-shift Clustering

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)

Students will able to:

CLO1	Demonstrate in-depth knowledge of methods and theories in the field of machine learning. To provide an introduction to the basic principles, techniques, and applications of Machine Learning, Classification Tasks, Decision tree learning.
CLO2	Understand and use Bayesian perspective on machine learning, Artificial neural networks, back propagation algorithm
CLO3	Assess learning algorithms modelled after biological evolution, including genetic algorithms and genetic programming.
CLO4	Assess explanation-based learning that uses prior knowledge to explain observed training examples, then generalizes based on these explanations and discuss approaches to combining approximate prior knowledge with available training data in order to improve the accuracy of learned hypotheses.
CLO5	Demonstrate knowledge of the disciplinary foundation and of proven experience in the design and analysis of learning algorithms and systems. To demonstrate the ability to critically evaluate and compare different learning models and learning algorithms and be able to adapt or combine some of the key elements of existing machine learning algorithms to design new algorithms as needed.

PHU004 RESEARCH METHODOLOGY, ETHICS AND IPR

Unit 1 Random Variables: Introduction to discrete and continuous random variables, probability Mass Function Cumulative Distribution Function (CDF), Functions of a Random Variable, Expected Value of a Derived Random Variable ,Variance and Standard Deviation, Conditional Probability Mass Function. Continuous random variables: The Cumulative Distribution Function (CDF), Probability Density Function (PDF).Statistical Distributions: Properties and applications of Normal, log-normal and t-distributions, Chi-Square and F distributions, properties of normal curve, applications of normal curve. Measure of shape: skewnessand Kurtosis. [T1,T2, R1]

Unit 2 Statistical Inference: Concept of standard error and its uses. The significances of statistical measures, Test of the significance difference between two means: Z-Test, T-Test, Analysis of variance and analysis of covariance: Assumptions of ANOVA, one way ANOVA, two way ANOVA. Post Hoc tests: Duncan's multiple range test, Tukey's test. Non-parametric tests: chi-square test, medium test, Friedman test, Wilcoxon test, Nemenyi test.

Unit 3 Regression: The Simple Regression Model, Multiple Regression Analysis: Estimation, Multiple Regression Analysis: Inference, Multiple Regression Analysis: OLS Asymptotics..Multiple Regression Analysis with Qualitative Information: Binary (or Dummy) Variables. Heteroskedasticity.

Unit 4 Ethics: Values, Morals and 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, Whistle-Blowing, Corporate Social Responsibility, Case Studies on Ethics in Business.

Unit 5 Introduction to IPR: Nature and Enforcement, International Character of IPRs, Role of IPRs in Economic Development. Patents: Introduction To Patents, Object of Patent Law, Inventions not Patentable, Obtaining Patents, Rights and Obligations of a Patentee.

Text Books:

1. Ken Black: Business Statistics for contemporary decision making, Wiley India, 5thedition, 2009.
2. Montgomery, D. C., G.C. Runger,Applied Statistics and Probability for Engineers. 5th ed. New Delhi: Wiley-India, 2011.
3. Roy D. Yates, David J. Goodman, Probability and Stochastic Processes : A Friendly Introduction for Electrical and Computer Engineers, Second edition, John Wiley and Sons,2005.
4. Narayanan, P., Intellectual Property Law, Eastern Law House (2007).

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 currenttransaction 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, HyperledgerSawtooth, Hyperledger fabric, Hyperledgerindy, Hyperledgeriroha.Hyperledger suitability according to project. Tools in Hyperledger: Caliper, composer, explorer.

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.

PCS234 DATA WAREHOUSE AND DATA MINING				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4**

Course Objectives: This course will introduce the concepts, techniques, design and applications of data warehousing and data mining. The course is expected to enable students to understand and implement classical algorithms in data mining and data warehousing.

Data Mining fundamentals. Data mining, Data Mining Functionalities, Classification of Data Mining systems, Major issues in Data Mining, Data object & attribute types.

Data Pre-processing: Need of Pre-processing the Data, Data Cleaning, Data Integration, Data Reduction, Data Discretization.

Data Warehousing: Introduction, Operational Data stores, ETL, Data Warehouses, Data Warehouse design & usage, Data Warehouse Metadata, Data Warehouse modeling-OLAP, Characteristics of OLAP systems, Multidimensional view and data cube, Data cube operations.

Mining frequent patterns and associations: Introduction, Association rules mining, Naive algorithm, Apriori algorithm, Apriori TID, Direct hashing and pruning (DHP), Dynamic Item set counting (DIC), Mining frequent pattern without candidate generation.

Classification: Introduction, Decision Tree Induction– split algorithm based on information theory, split algorithm based on Gini index, Bayes Classification Method, Rule Based classification, Model Evaluation & Selection.

Cluster analysis: Introduction, Partitional methods- K-Means algorithm, Hierarchical methods, Density based methods, Grid based methods, Evaluation of clustering.

Web data mining: Web Terminology and Characteristics, Locality and Hierarchy in the web, Web Content Mining, Web Usage Mining, Web Structure Mining.

Laboratory Work: The lab will cover data mining techniques-classification, clustering, and association rule mining and Data warehousing.

Recommended Books:

1. Han J., Kamber M. and Pei J., Data mining concepts and techniques, Morgan Kaufmann Publishers (2011).

2. Pudi V., Krishana P.R., Data Mining, Oxford University press, (2009) .

3. G.K Gupta "Introduction To Data Mining With Case Studies", PHI Learning Pvt. Ltd.

4. Adriaans P., Zantinge D., Data mining, Pearson educations press (1996).

5. *Pooniah P., Data Warehousing Fundamentals, Willey inderscience Publication, (2001).*

6. P.N. Tan, M. Steinbach, V. Kumar. Introduction to Data Mining Addison-Wesley 2005.

Course Learning Outcomes (CLOs)

On completion of this course, students will be able to

CLO1	Comprehend the concepts of data mining, data preprocessing techniques and Data warehouses.
CLO2	Understand and apply frequent pattern mining techniques for market basket analysis.
CLO3	Perform classification of data by using decision tree, split algorithm based on information theory, Gini index and Naïve Bayes.
CLO4	Demonstrate clustering of data by using partitioned methods, hierarchical methods density based methods and Grid based methods.
CLO5	Comprehend the techniques and use of web data mining.

PCS235 WEB SEARCH AND INFORMATION RETRIEVAL

L	T	P	Cr
3	0	2	4

Course Objectives: To have an advanced level of understanding of common and emerging methods of organizing, summarizing, and analyzing large collections of unstructured and lightly-structured text.

Introduction: Text analysis, Types of text analysis, Information retrieval, IR system architecture: Text processing, Indexes and query matching, Text processing: Text format, Tokenization, stemming, lemmatization, Language modeling, Examples of open source IR Systems.

Informational Retrieval: Query processing models. Probabilistic models (Binary independence model, Robertson/Spark Jones weighting formula, Two-Poisson model), Relevance feedback (Term selection, Pseudo relevance feedback); Language models: Unigram, Bigram language models, Generating queries from documents, Language models and smoothing, Ranking with language models, Kullback Leibler divergence, Divergence from randomness, Passage retrieval and ranking.

Management of Information Retrieval Systems: Knowledge management, Information management, Digital asset management, Network management, Search engine optimization, Records compliance and risk management, Version control, Data and data quality, Information system failure.

Types of information retrieval systems: Web retrieval and mining, Semantic web, XML information retrieval, Recommender systems and expert locators, Knowledge management systems, Decision support systems, Geographic information system(GIS).
Indexing: Inverted indices, Index components and Index life cycle, Interleaving Dictionary and Postings lists, Index construction, Query processing for ranked retrieval, Compression: General-purpose data compression, Symbol-wise data compression, Compressing posting lists, Compressing the dictionary.

Recommender Systems: Collaborative filtering and content-based recommendation of documents and products.

Information categorization and filtering: Classification, Probabilistic classifiers, linear classifiers, Similarity-based classifiers, Multi category ranking and classification, learning to rank, Introduction to the clustering problem, Partitioning methods, Clustering versus classification, Reduced dimensionality/spectral methods.

Sentiment Analysis: Introduction to sentiment analysis, Document-level sentiment analysis, Sentence-level sentiment analysis, Aspect-based sentiment analysis, Comparative sentiment analysis, baseline algorithm, Lexicons, Corpora, Tools of Sentiment analysis, Applications.

Web Search: Search engines; spidering; metacrawlers; directed spidering; link analysis (e.g. hubs and authorities, Google PageRank); shopping agents.

Laboratory Work: In Laboratory Assignments students can learn search engines and common open-source software to perform common methods of exploratory and predictive analysis and apply text analysis techniques discussed in class to solve problems of data analysis.

Recommended Books

1. *Butcher S., Clarke C.L.A., CormackG. Information Retrieval, MIT (1964).*
2. *Bates M.J., Understanding Information Retrieval Systems, CRC press (2010).*
3. *Manning C.D., Raghavan P. and Schütze H. Introduction to Information Retrieval, Cambridge University Press (2008).*
4. *Baeza-Yates R., Ribeiro-Neto B., Modern Information Retrieval, Addison-Wesley (1999).*
5. *Croft B., Metzler D. and Strohman T., Search Engines: Information Retrieval in Practice(2010).*

PCS236 DEEP LEARNING

L T P Cr

3 0 2 4.0

Course objective: There have been many recent advances in the field of deep learning. The objective of the course is to provide exposure to these advances and facilitate in-depth discussion on chosen topics.

Machine Learning Basics: Learning, Underfitting, Overfitting, Estimators, Bias, Variance, Maximum Likelihood Estimation, Bayesian Statistics, Supervised Learning, Unsupervised Learning and Stochastic Gradient Decent

I**Feedforward neural network:** Artificial Neural Network, activation function, multi-layer neural network.

Training Neural Network: Risk minimization, loss function, backpropagation, regularization, model selection, and optimization.

Conditional Random Fields: Linear chain, partition function, Markov network, Belief propagation, Training CRFs, Hidden Markov Model, Entropy.

Deep Learning: Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network.

Probabilistic Neural Network: Hopfield Net, Boltzman machine, RBMs, Sigmoid net, Autoencoders.

***Text Books*:**

1) *Ian Goodfellow and Yoshua Bengio and Aaron Courville,"Deep Learning", MIT Press, 2016*
2) *Michael Nielsen, "Neural Network and Deep Learning", Online Book 2016*

PCS 237 BIG DATA ANALYTICS

L	T	P	Cr
3	0	2	4

Course Objective: To have an advanced level of understanding of most recent advancements in Big Data and using insights, statistical models, visualization techniques for its effective application in Business intelligence.

Introduction to Data Analytics: Data and Relations, Data Visualization, Correlation, Regression, Forecasting, Classification, Clustering.

Big Data Technology Landscape: Fundamentals of Big Data Types, Big data Technology Components, Big Data Architecture, Big Data Warehouses, Functional vs. Procedural Programming Models for Big Data.

Introduction to Business Intelligence: Business View of IT Applications, Digital Data, OLTP vs. OLAP, BI Concepts, BI Roles and Responsibilities, BI Framework and components, BI Project Life Cycle, Business Intelligence vs. Business Analytics.
Big Data Analytics: Big Data Analytics, Framework for Big Data Analysis, Approaches for Analysis of Big Data, ETL in Big Data, Introduction to Hadoop Ecosystem, HDFS, Map-Reduce Programming, Understanding Text Analytics and Big Data, Predictive analysis on Big Data, Role of Data analyst.

Business implementation of Big Data: Big Data Implementation, Big Data workflow, Operational Databases, Graph Databases in a Big Data Environment, Real-Time Data Streams and Complex Event Processing, Applying Big Data in a business scenario, Security and Governance for Big Data, Big Data on Cloud, Best practices in Big Data implementation, Latest trends in Big Data, Latest trends in Big Data, Big Data Computation, More on Big Data Storage, Big Data Computational Limitations.

Laboratory Work: Introduction, use and assessment of most recent advancements in Big Data technology along with their usage and implementation with relevant tools and technologies.

Recommended books:

1. *Minelli M., Chambers M., Dhiraj A., Big Data, Big Analytics: Emerging Business*
2. *Intelligence and Analytic Trends for Today's Businesses, Wiley CIO Series (2013),*
3. *White T., Hadoop: The Definitive Guide, O' Reilly Media (2012).*

Course Learning Outcomes (CLOs)

CLO1	To comprehend the concepts of big data, architecture and environment, digital data types, structure and its implementation.
CLO2	Explore the advanced level of understanding of the usage of Big Data in present World.
CLO3	To comprehend the concepts of Map-Reduce, HDFS command and Hadoop services and its implementation.
CLO4	Analyze big data, create statistical models, and identify insights that can lead to actionable results
CLO5	To Use software tools such as R and Hadoop, in text analytics.

PCS208 RECOMMENDER SYSTEM				
	L	**T**	**P**	**Cr**
	3	**0**	**2**	**4**

Course Objective: To develop state-of-the-art recommender systems that automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations

Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system.

Content-based Recommendation: High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, Discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms.

Collaborative Filtering: User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems.

Knowledge based Recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders.

Ensemble-Based and Hybrid approaches: Opportunities for hybridization, Ensemble Methods from the Classification Perspective, Different types of Hybrids, Monolithic hybridization design, Parallelized hybridization design, Pipelined hybridization design, Limitations of hybridization strategies.

Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics.

Recommender Systems and Communities: Introduction to the basic concepts of collaboration and recommender systems in personalized web search, Context-Sensitive Recommender Systems, Time- and Location-Sensitive Recommender Systems, Structural Recommendations in Networks, Social, Group and Trust-centric Recommender Systems, Attack-Resistant Recommender Systems.

Laboratory Work: To implement algorithms and techniques given above using relevant tools or high level language. To design recommendation system for a particular application domain.

***Recommended Books**:*

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press (2011).
2. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer (2011).
3. Aggarwal C.C., Recommender Systems: The Textbook, Springer (2016).
4. Falk K., Practical Recommender Systems, Manning Publications (2019).

Course Learning Outcomes (CLOs)

CLO1	To comprehend the design of recommender systems: the underlying concepts, design space, and tradeoffs.
CLO2	To analyze the recommender systems based on collaborative filtering methods,

	Content based filtering approach and knowledge based approach.
CLO3	Explore construction and implementation of a hybrid recommender system.
CLO4	Evaluate the quality of recommendation systems through various evaluation parameters.
CLO5	Compare the user and community behaviour of recommendation systems and its implementation.

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 LanguageProcessing: 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.

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, 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.

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.

PCS214 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

PCS241 DIGITAL FORENSICS AND ETHICAL HACKING

L	T	P	Cr
3	0	2	4

Course Objectives: This course is designed to provide hands-on experience in different computer forensics situations that are applicable to the real world. This course will provide theoretical and practical knowledge on ethical hacking and digital forensics to investigate, detect and prevent digital crimes.

Introduction: Security, Essential Terminology, Elements of Security, Computer Forensics Fundamentals, Benefits of Computer Forensics, Computer Crimes and Implications, Computer Forensics Evidence and the Courts, Legal Concerns and Privacy Issues, Penetration Testing and Ethical Hacking, Phases of Ethical Hacking

Forensics Process: Forensics Investigation Process, Securing the Evidence and Crime Scene, Chain of Custody, Law Enforcement Methodologies, Forensics Evidence, Evidence Sources, Evidence Duplication, Preservation, Handling, and Security, Collection of Evidence on a Live System, Court Admissibility of Volatile Evidence, Network and mobile forensics tools and techniques.

Acquisition and Duplication: Sterilizing Evidence Media, Acquiring Forensics Images, Acquiring Live Volatile Data, Data Analysis, Metadata Extraction, File System Analysis, Performing Searches, Recovering Deleted, Encrypted, and Hidden files, Internet Forensics, Reconstructing Past Internet Activities and Events, E-mail Analysis, Messenger Analysis

Reconnaissance and Scanning: Information Gathering Methodology, Locate the Network Range, Active and Passive reconnaissance, Scanning, Elaboration phase, active scanning using various tools, Enumeration, Detecting live systems on the network, Discovering services running/listening on target systems, Understanding port scanning techniques, Identifying TCP and UDP services running on the network

Session Hijacking: Understanding Session Hijacking, Phases involved in Session Hijacking, Types of Session Hijacking, and Session Hijacking Tools.

System-Hacking-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.

Hacking Wireless Networks: Introduction to 802.1I, Role of WEP, Cracking WEP Keys, Sniffing Traffic, Wireless DOS attacks, WLAN Scanners, WLAN Sniffers, Hacking Tools, Securing Wireless Networks.

Laboratory work: Lab Exercises include forensic investigation tools (from Item confiscated to submitting evidence for lawful action), such as FTK, Sleuth Toolkit (TSK), Autopsy, etc.
Scanning tools like IPEYE, IPsecScan, SuperScan etc. and Hacking Tools likes Trinoo, TFN2K, Zombic, Zapper etc.

Recommended Books

1. *Sammons J., The Basics of Digital Forensics, Elsevier, (2015)*
2. *Eric Core, Hackers Beware, EC-Council Press, (2003)*
3. *McClure, S., Scambray, J., Kurtz, G. and Kurtz, Hacking exposed: network security secrets and solutions (2009)*

4. *Marcella J. A. and Guillossou F., Cyber Forensics: From Data to Digital Evidence, Wiley (2012).*

Course Learning Outcomes (CLOs)

CLO1	Analyze & demonstrate the crime scene and criminology.
CLO2	Apply digital forensic tools to discover, collect, preserve and analyze digital evidence.
CLO3	Exploit the vulnerabilities related to computer system and networks.
CLO4	Apply techniques of system hacking and hacking over a wireless network.

PCS242 DIGITAL WATERMARKING AND STEGANOGRAPHY

(L: T: P :: 3: 0: 2)

Unit 1: Introduction to Digital Image Watermarking, Applications, History, Classifications based of visibility, Classification based on resistance against attacks, Classification based on embedding and extraction of watermark, Properties of watermarks, Models of Watermarking, Attacks, Watermarking domains, Measure of evaluations

Unit 2: Introduction to Fragile watermark, Types and applications, Bit plane slicing, Generation of fragile watermark, Image and LSB based approach, Hash function, self embedding techniques, embedding of fragile watermark, Extraction of fragile watermark, Tamper detection, Content authentication, Fragile watermarks with recovery capabilities, embedding in spatial domain, embedding in frequency domain, semi-fragile watermarking.

Unit 3: Introduction to Robust watermarking, Robustness of the watermark, Types and Applications, Single vs multiple robust watermark, Encrypted robust watermark, Ownership assertion using robust watermark, Objective evaluation parameters, Subjective evaluation parameters, Duel watermarking, Types and applications, embedding sequence for dual watermarks, Authentication and authorization, Dual watermark with recovery capabilities. Tamper detection and recovery.

Unit 4: Introduction to Steganography, History, Watermarking vs staganography, Applications and Properties of steganography, Performance measures for stageography, Mathematical Notation and Terminology, Cachin's definition, Statistics preserving steganography, Model-based steganography, Minimizing the embedding impact, Preprocessing for steganography.

Unit 5: Introduction to Steganalysis, scenario, Types of steganalysis, Detection, Forensic steganalysis, The influence of the cover work, LSB Based steganalysis, Visual cryptography, Hybrid approach of various image based security techniques, Audio and video watermarking and steganography, 3D watermarking, 3D steganography.

Text Books (author, title, publisher and year):

- *I.J. Cox, Digital Watermarking and steganography, Morgan Kaufmann 2nd edition*
- *S. Shivani, Handbook of Image based security techniques, CRC Press (2018)1sted. other supplemental materials*

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

- Understand the fundamentals of digital image watermarking, its types and applications.
- Distinguish the concepts of fragile, robust, semi fragile and dual watermarking approaches.
- Understand the fundamentals of steganography and steganalysis, their types and applcations.
- Deploy the concepts Image based steganography and watermarking on other multimedia objects like audio, video, 3D models etc.

- Develop recoverable fragile watermark, Robust watermark, Dual watermarks and hybrid approaches of all image based security techniques in spatial and frequency domain of images.

PCS206 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.

PCS205 NETWORK SECURITY AND ETHICAL HACKING				
	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

5. *Eric Core, Hackers Beware, EC-Council Press, (2003)*
6. *William Stallings, Network Security Essentials, Prentice Hall, (2013)*
7. *William R. Cheswick and Steven M. Bellovin, Firewalls and Internet Security, Addison-Wesley Professional, (2003.)*
8. 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.

PCS251: Distributed Databases

L	T	P	Cr
3	0	2	4.0

Introduction to Distributed Database: Overview, Distributed DBMS, homogenous and heterogenous DDBMS, Parallel database and its comparison with distributed database, advantages and disadvantages of distributed database, data fragmentation, data replication, introduction to distributed transaction management, distribution concurrency control and distributed recovery, architecture of DDBMS.

Distributed and Parallel Database Design: Data fragmentation, allocation, combined and adaptive approaches to database design, data directory.

Distributed Data Control and Query Processing: Concept of views and view management, access control, integrity control, query processing problem, layers of query processing, query processing and optimization in distributed systems.

Distributed Transaction Processing and Concurrency Control: Transaction concept, ACID property, Objectives of transaction management, Types of transactions, Objectives of Distributed Concurrency Control, Concurrency Control anomalies, Distributed concurrency control algorithms, distributed reliability.

Distributed Deadlock & Recovery: Deadlock concept, Deadlock in Centralized systems, Deadlock in Distributed Systems – Detection, Prevention, Avoidance, Wait-Die Algorithm, Wound-Wait algorithm, Recovery in DBMS - Types of Failure, Methods to control failure, Different techniques of recoverability, Write- Ahead logging Protocol.

Laboratory Work: To implement various concepts of distributed database studied during course.

Course Learning Outcomes: After the completion of course, students will be able to

1. understand the different architectures of distributed DBMS.

2. explain the design of distributed databases.

3.understand distributed query processing in distributed databases.

4. comprehend distributed concurrency control and transaction processing mechanisms.

5. Recognize causes for database failures and different types of recovery techniques.

Text Books:

1. Principles of Distributed Database Systems, M. Tamer Özsu and Patrick Valduriez, Prentice Hall, 1999.

2. Distributed Database Management Systems: A Practical Approach, Saeed K. Rahimi and Frank S. Haug, IEEE Computer Society, Wiley, 2010.

Reference Books:

1. Distributed Databases - Principles and Systems; Stefano Ceri; GuiseppePelagatti; Tata McGraw Hill; 1985.

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.

Course Learning Outcomes (CLO):

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.

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).*

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.

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 – Prototyping in practice – design rationale. Design rules – principles, standards, guidelines, rules. Evaluation Techniques – Universal Design.

Models and Theories: 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*

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

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