M. Tech (Data Science & AI) Electives Syllabus

Electives I/II

CS-5007	Advanced Data Structures and algorithms	L-T-P-C:3-1-0-4

Course objective:

- The course is intended to provide the foundations of the practical implementation and usage of Algorithms and Data Structures. One objective is to ensure that the student evolves into a competent programmer capable of designing and analyzing implementations of algorithms and data structures for different kinds of problems. The second objective is to expose the student to the algorithm analysis techniques, to the theory of reductions, and to the classification of problems into complexity classes like NP

Course content:

Unit 1 Advanced Data Structures

Importance and need of good data structures and algorithms, Heaps, AVL Trees (Search, Insertion, and ,Deletion), Red-Black Trees (Search, Insertion, and Deletion), Splay Trees (Search, Insertion and Deletion), B trees, B+ Trees (Search, Insertion and Deletion), Fibonacci heaps, Data Structures for Disjoint Sets, Augmented Data Structures, Self-Adjusting Data Structures, Temporal data structures, Succinct data structures, Dictionaries and cuckoo hashing.

Unit 2 Algorithms Complexity and Analysis

Probabilistic Analysis with example, Amortized Analysis with example, Competitive Analysis with example, Internal and External Sorting algorithms like external merge sort, distribution sorts.

Unit 3 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, Topological sort, Max flow: FordFulkerson algorithm, max flow – min cut, Dynamic Graphs, Few Algorithms for Dynamic Graphs, Union-Find Algorithms.

Unit 4 Algorithms Terminology

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.
Genetic Algorithm: Introduction to GA, implementation in Python, problem solving using GA such as subset problem, TSP, Knapsack.

Unit 5 Advance Data Structure in Python
List, Tuple, Dictionary, Set, Stack.
Laboratory work: Implementation of various advanced data structures and algorithms for the problems like MAZE etc. Implementation of various advanced data structures with Graphs and GUI based results to explore the use of formal verification algorithms and verification tools.

Course outcome:

- Design and analyze programming problem statements.
- choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem.
- understand the necessary mathematical abstraction to solve problems.
- come up with analysis of efficiency and proofs of correctness
- comprehend and select algorithm design approaches in a problem specific manner**.**

Text Book:

1. Cormen, Leiserson, Rivest, & Stein, Introduction to Algorithms, The MIT Press (2009), 3rd Edition.
2. Goldberg, Genetic Algorithms, Pearson Education India (1 December 2008), 1st Edition.
3. Sedgewick & Wayne, Algorithms, Addison-Wesley Professional (March 19, 2011), 4th Edition.

Reference Book:

1. Sahni, Data Structures, Algorithms and Applications in C++, Universities Press (2005), 2nd Edition.

CS-5009	**Software and System Engineering**	**L-T-P-C:3-1-0-4**
Course objective:	• To discuss various System design methodologies, the impact of cohesion and coupling measures on the goodness of the software design. • To discuss various System Testing methodologies • To discuss the importance of practicing different coding standards, guidelines along with reliability metrics and management techniques & standards.	

Course content:

UNIT 1

Introduction

Importance of System Engineering Paradigms for Software Systems; Life Cycle Models- Project scheduling and tracking, System Configuration Management.

UNIT 2

Requirement Analysis – Functional Modelling of Software Systems

Requirements Analysis and Specifications, Analysis Modeling, Design Concepts and Principles, Function-oriented design, Architectural design, User Interface Design, Component Level Design. UML Modelling

UNIT 3

Quality Assurance of Software Systems

Testing Techniques for Software Systems: Black box and White box Testing, Regression testing, Reliability Modelling of Software Systems, Quality Assurance and Maintenance

UNIT 4

Measurement of Software Systems

Metrics for Measurement of Software Systems, Direct Measurement, Indirect Measurement: Product Metrics: Product metrics Process Metrics, Project Metrics

UNIT 5

Software Configuration Management

Change Requirements, Version control, Change management, scheduling, estimating, etc. Manual and Automatic Test Data Generation for Software Systems/Embedded Systems.

Course outcome:	After reading this subject, students will be able to: • Choose a proper life cycle model for different real life industrial applications, design software using function-oriented approach (DFDs) and object-oriented approach (UML diagrams). • Understand the concepts of computer aided software engineering (CASE) and use different CASE tools in the development, maintenance and reuse of software systems. • Know the emerging concepts like SOA etc., their functioning and their applications in real life problems.
Text Book:	1. R. S. Pressman, Software Engineering A Practitioner's Approach, McGraw Hill Publications , 2006 2. R. Mall, Fundamentals of Software Engineering, Prentice Hall of India , 2014
Reference Book:	1. I. Sommerville, Software Engineering, Pearson Education, Asia , 2006 2. P. Jalote, An Integrated Approach to Software Engineering, Narosa

	, 2006

CS-5011	Stochastic Processes and Queuing Theory	L-T-P-C: 3-1-0-4

Unit-I

Poisson Processes : Introduction to stochastic processes, Poisson process: Definition, Properties of Poisson processes, Generalization of Poisson processes

Unit-II

Renewal Theory and Regenerative Processes: Renewal Process: Introduction, Limit Theorems, Blackwell's Theorem, Renewal Equation, Renewal theorems, Regenerative Processes

Unit-III

Discrete Time Markov Chains: Markov Chains: Definitions, Class Properties of Transience and Recurrence, Limiting distributions of Markov chains, Tests for transience, null recurrence and positive recurrence, Reversible Markov Chains, Rate of convergence to the stationary distribution

Unit-IV

Continuous-Time Markov Chains: Introduction, Markov property, Minimal construction, Chapman Kolmogorov equations, Irreducibility and Recurrence, Time Reversibility, Birth-Death process, Reversibility of Birth-Death process

Unit-V

Martingales: Introduction, Sampling Theorem, Martingale inequalities, McDiarmid's Inequality: Applications, Martingale Convergence Theorem, Applications to Markov chain,

Random Walks Definitions, Ladder Heights, Maxima, GI/GI/1 Queue, Ladder Epochs

Unit-VI

Queuing Theory: GI/GI/1 Queue, Palm Theory, PASTA, Rate conservation laws, PASTA, Product-form Networks, M/M/1 queue, Tandem Queues, Open Jackson, Closed queueing networks, Product-Form Networks: Quasireversible networks, Quasireversible Queues, Networks of Quasireversible Queues.

Text Book

[1] Stochastic Processes, Sheldon M. Ross, 2nd edition, 1996.
[2] Introduction to Stochastic Processes, Erhan Cinlar, 2013.
[3] Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues, Pierre Bremaud, 1999.

Reference Books

[1] S. Assmussen,"Applied Probability and Queues", 2nd ed., Springer, 2003.
[2] B. Hajek,"Random Processes for Engineers", Cambridge Univesity press, 2015.
[3] S. Karlin and H.M. Taylor,"A First Course in Stochastic Processes", 2nd ed., 1975. [4] S.M. Ross, "Stochastic Processes",2nd ed., Wiley, 1996.
[5] J. Walrand,"An introduction to Queueing Netwoorks", Prentice Hall, 1988.

CS-5013	Ethics and Data Science	L-T-P-C: 3-1-0-4

Unit-I

Overview of ethical issues in data-driven organizations: Overview of data science as an ethical practice, Introduction to the unique ethical challenges of 'big data', Ethical Theory - Philosophical frameworks for

assessing fairness, Early theories of fairness, Moving towards contemporary theories of fairness.

Unit-II

Research ethics for data science: Ethical side effects of the publish or perish system: p-hacking and small sample size, The misapplication of informed consent in dataveillance practices. Techniques of data ethics: Getting from data to individuals: Internet traces and Geofingerprints. All data are human data: On the discriminatory trouble with training data.

Unit-III

Discrimination and algorithms: The ethics of price discrimination, Criminal justice by algorithm. The philosophical challenge of thinking in categories-How humans explain their social worlds through perceptions and statistics, Social processes and the impact of categorical life. Data ethics for researchers-Health Research, Educational Research.

Unit-IV

The ethics of data scraping and storage, Mosaic data, found data, and designed data.

Unit-V

Privacy and Surveillance, Special topics in surveillance: Adtech, Special topics in surveillance: Employment, Differential privacy.

Text Book

[1] Ethics and Data Science, by DJ Patil, Hilary Mason, and Mike Loukides, 25 July 2018.

CS-5015	WEB SERVICES AND E-COMMERCE	L-T-P-C: 3-1-0-4

Unit-I

Introduction to XHTML and Javascript, XML Elements and Attributes, XML Document Structure and Syntax, XML Namespaces, XML Data Validation, XML 1.1 new features, XML Namespaces, XML parsers for data validation, Document Type Definitions, W3C XML Schemas.

Unit-II

Parsing XML with Document Object Model (DOM), Parsing XML and with Simple API for XML(SAX), XSLT concepts and transformations, Storing and Binding data in HTML, Navigation from record to record, Extracting data from DSO, Binding XML data into HTML tables, Reading XML and Extracting data from it, Creating a DOM Document Object, Getting a Document's Document Element, Searching for XML Elements by name, Extracting Data from XML attributes, Xquery and its usage.

Unit-III

Design of Information system, Architecture of an Information system, Understanding Middleware, RPC and related Middleware, TP Monitors, object Brokers, Message Oriented Middleware, Web Service concept, SOAP, WSDL, UDDI, Creating and Deploying, Accessing and Building .NET Web Services, Authentication and Security for Web Services; Major components of e-Commerce, e-Commerce framework, Media Convergence.

Unit-IV

Anatomy of e-Commerce application, Types of e-Commerce: Inter-organizational, Intra-organizational, C2B, Communication Security goals; E commerce privacy policy, Network security policy, Firewall security policy, Requirements of transaction security, E commerce encryption, Digital Money Security Payment Transaction, Electronic Security basics, Limitation of e-Commerce, Security measures.

Text Book

[1] Web Services Security and E-business, by Radhamani, G., Rao, G. S.V. Radha Krishna, Idea Group

Inc (IGI), 31-Oct-2006.

CS-5017	Pattern Recognition	L-T-P-C: 3-1-0-4

Course objective: The objective of the course is to understand the algorithms for Pattern Recognition. The representation of patterns and classes and the similarity measures are an important aspect of pattern recognition. Pattern recognition involves classification and clustering of patterns. The two well-known paradigms of machine learning namely, learning from examples or supervised learning and learning from observations or clustering covered in this course. When the data sets are very large it is meaningful to reduce the data and use this reduced data for pattern classification. The details of feature extraction and feature selection are also covered in this course.

Unit-I

Introduction: Basics of Probability and Statistics, Linear Algebra, Linear Transformations, Components of Pattern Recognition System, Learning and adaptation, Supervised Learning (Classification) and Unsupervised Learning (Clustering)

Unit-II

Bayesian Decision Theory: classifiers, discriminant functions, decision surfaces, Discriminant functions for Normal density, Error bounds for Normal density, Maximum Likelihood and Bayesian Parameter Estimation, Maximum a Posteriori estimation. Non-parametric Techniques: Parzen window estimation, *k*-nearest neighbour classification, Perceptron classifier.

Unit-III

Artificial neural networks: Types, Topology. Multilayer perceptron - feedforwark neural network. Back propagation networks : (BPN) Architecture of feed forward network, single layer ANN, multilayer perceptron, back propagation learning, input – hidden and output layer computation, back propagation algorithm, applications, selection of tuning parameters in BPN, learning.

Basic functional units of ANN for pattern recognition tasks: Basic feed forward, Basic feedback and basic competitive learning neural network. Pattern association, pattern classification and pattern mapping tasks. Analysis of pattern storage problem, store and recall in Hopfield Network.

Unit-IV

Complex pattern recognition task, RBFN, Counter Propagation Network, Recurrent Networks, Fully Connected Recurrent Networks, Temporal patterns.

Unit-V

Competitive learning neural networks : Components of CL network pattern clustering and feature. Mapping network, Unsupervised learning and clustering - Criterion functions for clustering. Similarity measures. Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation, Single linkage and Complete linkage clustering.

Text Book

[1] R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001

[2] Artificial Neural Network, B. Yegnarayana

Reference Book:

[3] S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009

[4] C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

CS-5019	IoT Architecture & Computing	L-T-P-C:3-1-0-4

Course objective:

- To learn how to design and implement IoT applications that manage big data, streaming data, and/or distributed data
- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols

- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

Unit I

Fundamentals of IoT: Evolution of Internet of Things, Enabling Technologies, IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models, Simplified IoT Architecture and Core IoT Functional Stack, Fog, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects

Unit II

IoT Protocols: IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN, Zigbee protocol, Network Layer: IP versions, Constrained Nodes and Constrained Networks, Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Transport Methods: Supervisory Control and Data Acquisition, Application Layer Protocols: CoAP and MQTT

Unit III

Design and Development: Design Methodology, Embedded computing logic, Microcontroller, System on Chips, IoT system building blocks, Arduino–Board details, IDE programming, Raspberry Pi and Interfaces

Unit IV

Data Analytics and Supporting Services: Structured Vs Unstructured Data and Data in Motion Vs Data in Rest, Role of Machine Learning-No SQL Databases, Hadoop Ecosystem, Apache Kafka, Apache Spark, Edge Streaming Analytics and Network Analytics, Xively Cloud for IoT, Python Web Application Framework, Django, AWS for IoT, System Management with NETCONF-YANG, Kibana, Fault-tolerant data processing on devices

Unit V

Case Studies/Industrial Applications: Cisco IoT system, IBM Watson IoT platform, Manufacturing, Converged Plantwide Ethernet Model (CPwE), Power Utility Industry, GridBlocks Reference Model, Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

Course outcome: At the end of the course, student will able to

- Describe the term IoT in different contexts.
- Analyze various protocols for IoT.
- Design a PoC of an IoT system using Rasperry Pi/Arduino
- Apply data analytics and use cloud offerings related to IoT.
- Analyze applications of IoT in real time scenario

Text Book:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals:Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017
2. Arshdeep Bahga, Vijay Madisetti, Internet of Things – A hands-on approach, Universities Press, 2015

Reference Book:

1. Olivier Hersent, David Boswarthick, Omar Elloumi , The Internet of Things – Key applications and Protocols, Wiley, 2012
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand, DavidBoyle, From Machine-to-Machine to the Internet of Things –Introduction to a New Age of Intelligence, Elsevier, 2014.
3. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), Architecting the Internet of Things, Springer, 2011.
4. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

CS-5021	Evolutionary and Randomized Algorithms	L-T-P-C:3-1-0-4

Course objective:

- The objective of this course is to familiarize students with some contemporary research in the emerging areas of algorithm design and analysis such as techniques to solve optimization problems and use of randomness to help in computing.
- The main focus will be on the details of the techniques such as ACO, PSO and artificial neural System and related learning algorithms

Course content:

Unit-I: Reducibility between problems and NP-completeness:

Computational Models; Problems, computability, Algorithms, Resources, and Complexity; Turing machines (time and space bounds, non-determinism); Complexity classes (hierarchy theorem, P, NP, Co-NP, NP-hard); Reduction and completeness; Polynomial Hierarchy; Logarithmic space; Polynomial space; Exponential time and space; Discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, TSP, knapsack, set cover, bin packing, etc.

Unit II: Evolutionary Computation:

Introduction to Models and Concept of Computational Intelligence, Social Behavior as Optimization: Discrete and Continuous Optimization Problems, Classification of Optimization Algorithms, Evolutionary Computation Theory and Paradigm, Genetic Algorithm, Genetic Representations, Initial Population, Fitness Function, Selection and Reproduction, Genetic Operators (Selection, Crossover, Mutation), Artificial Immune Systems, Other Algorithms Harmony Search, Honey-Bee Optimization, Memetic Algorithms, Co-evolution, MultiObjective Optimization, Artificial Life, Constraint Handling

Unit-III: Neural Networks:

Neuron Models, Neuron Architecture, Mathematical Model of Neural Networks, , Artificial Neural Network Learning Methods and Learning Strategies, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Activation Functions, Pattern Classification and Linear Separability, Single and Multilayer Perceptron Network, Self-Organizing Map (Kohonen network), Hopfield Network, Back Propagation Network, Radial Basis function Network

Unit-IV: Swarm Intelligence

Swarm and Collective intelligence, Swarm Intelligence Techniques: Particle Swarm Optimization, Ant Colony Optimization, Artificial Bees and Firefly Algorithm etc., Hybridization and Comparisons of Swarm Techniques, Artificial evolution of Competing Systems, Artificial Evolution of cooperation and competition, Application of Swarm Techniques in Different Domains and Real World Problems.

Unit-V: Randomized Algorithms:

Probabilistic Recurrence, Basic Power and Efficiency of Randomization and Approximation, Classification of randomized algorithms: Las Vegas and Monte Carlo, Minimum cut algorithm, Bin-Balls Problem, Birthday-Paradox, Coupon-Collector, Stable Marriage Problem, Game Theory, Random variables and Basic inequalities (Markov, Chebyshev), Chernoff Bounds, Martingale Bound, Max-cut, Random Graphs, Markov chains and random walks, Random graph models for real-world networks, social networks, etc. Algorithms for 2-SAT and 3-SAT.

Course outcome:

After completing this course, students will

Have working knowledge of Evolutionary Theory and Algorithms and be able to explain how biological systems exploit natural processes.

Understand the impact of using randomization for designing algorithms that are simpler and often more efficient than the deterministic counterparts

Text Book:

1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press.
2. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Second Edition, MIT Press/McGraw-Hill, 2001.
3. A.E. Elben and J. E. Smith, “Introduction to Evolutionary Computing”, Springer, 2010.
4. Eberhart, E. and Y. Shi., “Computational Intelligence: Concepts and Implementations”, Morgan Kauffmann, San Diego, 2007
5. Kenneth DeJong, Evolutionary Computation A Unified Approach, 2006.
6. Gusz Eiben and Jim Smith, Introduction to Evolutionary Computing, 2007.

Reference Book:

1. M. Kearns and U. Vazirani, An Introduction to Computational Learning Theory. MIT Press.
2. N. Alon and J. H. Spencer, The Probabilistic Method, John Wiley.
3. Christos H. Papadimitriou, Computational Complexity, Addison-Wesley Longman.
4. John E. Hopcroft and Jeffrey D. Ullman, Introduction to Automata, Languages and Computation, Addison-Wesley, 1979.
5. Bonabeau, E., Dorigo, M. and Theraulaz, G., Swarm Intelligence: From Natural to Artifical Systems, Oxford University Press, 1999
6. Dario Floreano, Claudio Mattiussi, “Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies”, MIT Press, 2008.
7. Engelbrecht, A.P. Computational Intelligence: An Introduction, Second Edition, John Wiley and Sons, 2007.
8. Kennedy, J. and Eberhart, R.C., Swarm Intelligence, Morgan Kaufmann Publishers, 2001
9. Parsopoulos, K.E., Vrahatis, M.N., Particle Swarm Optimization and Intelligence: Advances and Applications, Information Science Reference, IGI Global, 2010

10. D. E. Goldberg, "Genetic algorithms in search, optimization, and machine learning", AddisonWesley, 1989
11. R. C. Ebelhart et al., "Swarm Intelligence", Morgan Kaufmann, 2001.
12. M. Dorigo and T. Stutzle, "Ant Colony Optimization", A Bradford Book, 2004.
Simon O. Haykin, "Neural Networks and Learning Machines", Third Edition, Prentice Hall, 2008

CS-5109: Algorithms LAB

List of Lab Assignments / Experiments:

1. Design a randomized algorithm that can solve TSP. Find the complexity of it.
2. Design of randomized algorithms to break symmetry, to fool adversary in a communication network
3. Application of Genetic Algorithm as mini project
4. Application of PSO, ACO as mini projects
5. Use of neural network in machine learning as mini project

Electives III/IV

CS-5010	Software Defects and Quality Prediction Techniques	L-T-P-C:3-1-0-4

Course objective:

- To discuss various Ways of Measuring Software.
- To discuss On Different type of Software Metrics
- To discuss on various software defect prediction models.
- To discuss on Software Quality Prediction Models.

Course content:

Unit 1: Fundamentals of Measurements and Experimentation

Software Measurements, Software Metrics, Representational Theory of Measurements, Goal Based Framework for Software Measurements, Software Metrics and Data Collection, Analyzing Software-Measurements Data.

Unit 2: Software Defect Prediction

Software Testing, Software Defects, Bugs and Failures, Defect Prediction Based on Bugs, Defect Prediction Based on Metrics and other parameters.

Unit 3: Time Series Analysis of Software Defects

Basics of Time Series Analysis, Stationary and Non-Stationary Models of Time Series, Linear and Non-Linear Time Series Models for Software Defect Prediction, Advantages of Time Series Analysis over Other Prediction Models.

Unit 4: Software Reliability Prediction

Software Reliability, Software Reliability Prediction Models, Software Reliability Prediction

Based on Fault Data. **Unit 5: Research Project on Software Quality Prediction** Software Maintainability Prediction, Software Testability Prediction, Prediction of Non-Functional Requirements of Software, Quality Assurance and CMMI Models.	
Course outcome:	After reading this subject, students will be able to: • Will be helpful in Quantifying Software Quality and Better analysis of Software Internal Parameters. • Early Prediction of Software Reliability, Maintainability and Testability will be helpful in developing Better Quality Software.
Text Book:	1. R. S. Pressman, Software Engineering: A Practitioner's Approach, McGraw Hill Publications , 2006 2. R. Mall, Fundamentals of Software Engineering, PHI Learning , 2014
Reference Book:	1. I. Sommerville, Software Engineering, Pearson Education , 2006 2.A. Behferooz and F. J. Hudson, Software Engineering Fundamentals, Oxford University Press , 2000

CS-5012	**Simulation and Modeling**	**L-T-P-C: 3-1-0-4**

Unit-I

Introduction to simulation: Advantages & Dis-advantages of simulation – Areas of applications, Systems and Systems Environment, Concept of a system, Discrete & Continuous system – Models, types of models, Steps in a simulation study – Examples, Discrete – Event System simulation.

Unit-II

Overview of Statistical Models and Queuing Systems, Programming languages for Simulation: Continuous and Discrete Simulation Languages – GPSS, SIMAN, SIMSCRIPT, MATLAB and SIMULINK.

Unit-III

Random Numbers: Generation, Properties of Random Numbers, Generation of Pseudo Random Numbers, Tests for Random Numbers.

Random Variate: Generation, Inverse Transformation Technique, Uniform Distribution, Exponential Distribution, Weibul's Distribution, Triangular Distribution, Empirical Continuous Distribution, Discrete Distributions, Direct Transformation for the Normal Distribution, Convolution Method of Erlang Distribution, Acceptance Rejection Techniques: Poisson Distribution, Gamma Distribution.

Unit-IV

Input Data Analysis: Data Collection: Identify the Distribution, Parameter and Estimation.

Goodness of fit tests: Chi-Square Test – KS Test; Multivariate and time series input models, Verification and Validations of Simulation Models, Model Building, Verification and Validation: Verification of Simulation Models, Calibration and Validation of Models, face validity, Validation of Model Assumptions.

Validation Input/output Transformations, Input/output Validation using Historical Input Data, Input/output Validation Sing Turning Test.

Unit-V

Output Data Analysis, Stochastic, Nature of output data, Types of Simulation with respect to output Analysis, Measures of Performance and their Estimation, output Analysis for Terminating Simulations, Output Analysis for steady – State Simulations.

Comparison and Evaluation of Alternative System Designs: Comparison of several system Designs, Statistical Models for Estimating the Effect of Design Alternatives

Text Book:

1. Jabey Banks, John S. Cansen and Barry L. Nelson, Discrete – Event System Simulation, Prentice Hall of India, 2001.
2. Nursing Deo, System Simulation with Digital computer, Prentice Hall of India, 1979.
3. Anerill M. Law and W. David Kelton, Simulation Modelling and Analysis, McGraw Hill. 2001.
4. Agam kumar tyagi, MATLAB and Simulink for Engineers, Oxford Publishers, 2011

CS-5014	Real Time Data Analysis	L-T-P-C: 3-1-0-4

Course objective:

- To study issues related to the design and analysis of systems with real-time constraints.
- To learn the features of Real time OS.
- To study the various Uniprocessor and Multiprocessor scheduling mechanisms.
- To learn about various real time communication protocols.
- To study the difference between traditional and real time databases.
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Unit-I

Introduction to real time computing: Concepts; Example of real-time applications – Structure of a real time system – Characterization of real time systems and tasks - Hard and Soft timing constraints - Design Challenges - Performance metrics - Prediction of Execution Time : Source code analysis, Micro-architecture level analysis, Cache and pipeline issues- Programming Languages for Real-Time Systems

Unit-II

Real time OS: Threads and Tasks – Structure of Microkernel – Time services – Scheduling Mechanisms Communication and Synchronization – Event Notification and Software interrupt Task assignment and Scheduling

Unit-III

Task allocation algorithms: Single-processor and Multiprocessor task scheduling - Clock-driven and priority-based scheduling algorithms Fault tolerant scheduling

Unit-IV

Real Time Communication: Network topologies and architecture issues – protocols –contention based, token based, polled bus, deadline based protocol, Fault tolerant
routing. RTP and RTCP.

Unit-V

Real time Databases

Transaction priorities – Concurrency control issues – Diskscheduling algorithms – Two phase approach to

improve predictability

Course Outcome:

Upon Completion of the course, the students will be able to:

- Gain Knowledge about Schedulability analysis.
- Learn about the Real-time programming environments.
- Attain knowledge about real time communication and databases.
- Develop real time systems.

Text Book:

[1]C.M. Krishna, Kang G. Shin – " Real Time Systems", International Edition, McGrawHill Companies, Inc., New York, 1997.

[2]Jane W.S. Liu, "Real-Time Systems", Pearson Education India, 2000

Reference Book:

[1] Philip A. Laplante and Seppo J. Ovaska, "Real-Time Systems Design and Analysis:Tools for the Practitioner'' IV Edition IEEE Press, Wiley, 2013.

[2] Sanjoy Baruah, Marko Bertogna, Giorgio Buttazzo, "Multiprocessor Schedulingfor Real-Time Systems ", Springer International Publishing, 2015.

CS-5016	**Advanced Database Management Systems**	**L-T-P-C:3-1-0-4**
Course objective:	• To evaluate emerging architectures for database management systems. • To develop an understanding of the manner in which relational systems are implemented and the implications of the techniques of implementation for database performance. • To assess the impact of emerging database standards on the facilities which future database management systems will provide.	

Course content:

Unit 1 Theoretical concepts, Relational model conformity and Integrity, Advanced SQL programming

Unit 2 Query optimization, Concurrency control and Transaction management, Database performance tuning, Distributed relational systems and Data Replication

Unit 3 Object oriented, deductive, spatial, temporal and constraint database management systems, New database applications and architectures: e.g. Data Warehousing; Multimedia; Mobility; NoSQL, Native XML databases (NXD), Document orientated databases

Unit 4 SQL standards development, Standards for interoperability and integration e.g. Web Services

Unit 5 Database security - Data Encryption, redaction and masking techniques. Authentication and authorization. Database auditing

Course outcome:	After reading this subject, students will be able to: • Critically assess new developments in database technology • Interpret and explain the impact of emerging database standards • Evaluate the contribution of database theory to practical implementations of database management systems.

Text Book:

1. Date C. J., An Introduction to Database Systems, AddisonWesley Longman (8th Ed), 2003
2. Silberschatz A., Korth H., and Sudarshan S., Database System Concepts, McGraw-Hill (6th Ed), 2010

Reference Book:

3. Melton, J., & Simon A., SQL 1999, Understanding Relational Language Components, Morgan-Kaufmann, 2003.
4. Peter Adams : SQL: The Ultimate Guide from Beginner to Expert - Learn and Master SQL in No Time, Addison Wesley, 2016

CS-5018	**Big Data Analytics**	**L-T-P-C:3-1-0-4**
Course objective:	• To gain an understanding of Relational Database Management Systems • To gain an understand and use Structured Query Language • To gain an understanding of Data Analytics and Visualization • To gain an understanding of how managers use analytics to formulate and solve business problems and to support managerial decision making.	

Course content:

Course content:

Unit 1

Overview of Big Data, Stages of analytical evolution, State of the Practice in Analytics, The Data Scientist, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle

Unit 2

Operationalizing Basic Data Analytic Methods Using R, Advanced Analytics Analytics for Unstructured Data Map Reduce and Hadoop, The Hadoop Ecosystem

Unit 3

In database Analytics, Data Visualization Techniques, Stream Computing Challenges, Systems architecture

Unit 4

Main memory data management techniques, energy efficient data processing, Benchmarking, Security

and Privacy, Failover and reliability.

Unit 5

Machine Learning Algorithms Application in Data Analysis

Course outcome:	Upon successful completion of this course students should be able to: • These conclusions are made possible by using the various analytic tools currently available, i.e. MS Power • Business Intelligence(BI), Hadoop, Tableau, Excel, SAS, etc.

Text Book:

1. Business Intelligence Guidebook - From Data Integration to Analytics, First Edition, Rick Sherman
2. Morgan Kaufmann; 1 edition (November 21, 2014), 550 pages
   ISBN-10: 012411461X | ISBN-13: 978-0124114616 |

CS-5020	Cloud Computing	L-T-P-C:3-1-0-4

- To enable students to deliver an application built in the cloud with the concept of application-based building blocks for processing of data.
- To acquire the concept of cloud computing and to have knowledge on the various issues in cloud computing.
- To appreciate the emergence of cloud as the next generation computing paradigm.

Module I

Introduction: Introduction to Cloud Architecture and Computing Concepts, Why Clouds, What is a Cloud, Introduction to Clouds: History, What's New in Today's Clouds, New Aspects of Clouds, Economics of Clouds, cloud distributed system, MapReduce: Paradigm, Scheduling, Fault-Tolerance.

Module II

Multicast Problem and P2P Systems: Introduction to Multicast Problem, Gossip Protocol – analysis – implementation, Failure Detectors, Gossip-Style Membership, Dissemination and suspicion, Grid Applications, Grid Infrastructure, P2P Systems Introduction, Napster, Gnutella, FastTrack and BitTorrent, Chord, Pastry, Kelips.

Module III

Design of key-value/NoSQL storage/database systems: Introduction to Key-Value/NOSQL, Cassandra, Cap Theorem, Consistency Spectrum, HBase, Cristian's Algorithm, Network Time Protocol (NTP), Lamport Timestamps, Vector Clocks

Module IV

Machine Coordination in a Distribution system: The Election Problem, Ring Leader Election, Election in Chubby and ZooKeeper, Bully Algorithm, Distributed Mutual Exclusion, Ricart-Agrawala's Algorithm, Maekawa's Algorithm.

Module V

Transactions and Replication Controlling Cloud Systems: Remote Procedure Calls (RPCs), Transactions, Serial Equivalence, Pessimistic Concurrency, Optimistic Concurrency Control, Replication, Two-Phase Commit.

Module VI

Emerging Paradigms and Classical Systems: Stream Processing in Storm, Distributed Graph Processing, Structure of Networks, Single-processor Scheduling, Hadoop Scheduling, Dominant-Resource Fair Scheduling, File System Abstraction, Network File System (NFS) and Andrew File System (AFS), Distributed Shared Memory.

Course outcome:

After studying this course, the students will be able to

- Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
- Understand core techniques, algorithms, and design philosophies – all centered around distributed systems.
- Analyze and implement concepts include: clouds, MapReduce, key-value/NoSQL stores, classical distributed algorithms, widely-used distributed algorithms and scalability.
- Learn the key and enabling technologies that help in the development of cloud.
- Develop the ability to understand and use the architecture of compute and storage cloud, service and delivery models.
- Evaluate and choose the appropriate technologies, algorithms and approaches for implementation and use of cloud.

Text Book:

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, “Distributed and cloud computing from Parallel Processing to the Internet of Things”, Morgan Kaufmann, Elsevier, 2012.
2. Rittinghouse, John W., and James F. Ransome, “Cloud Computing: Implementation, Management and Security”, CRC Press, 2017.

Reference Book:

1. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, “Mastering Cloud Computing”, Tata Mcgraw Hill, 2013.
2. Toby Velte, Anthony Velte, Robert Elsenpeter, “Cloud Computing – A Practical Approach, Tata Mcgraw Hill, 2009.
3. Barrie Sosinsky, “Cloud Computing Bible” John Wiley & Sons, 2010.
4. Tim Mather, Subra Kumaraswamy, and Shahed Latif, “Cloud Security and Privacy An Enterprise Perspective on Risks and Compliance”, O'Reilly, 2009.

CS-5022	Deep and Reinforcement Learning Techniques	L-T-P-C:3-1-0-4

- To understand the fundamental principles and techniques in deep and reinforcement learning.
- Helps to understand different algorithms in deep and reinforcement learning.
- Helps to understand few applications of deep and reinforcement learning.
- To analyze few active research topics in deep and reinforcement learning areas.

Unit 1

Introduction

Introduction- Historical Trends in Deep Learning, Machine Learning Basics, History of Reinforcement Learning – Examples - Elements of Reinforcement Learning - Limitations and Scope.

Unit 2

Deep Networks

Deep Feedforward Networks-Example-Gradient-Based Learning-Hidden Units-Architecture Design- Back-Propagation and Other Differentiation Algorithms, Regularization for Deep Learning, Optimization for Training Deep Models - Challenges - Basic Algorithms - Parameter Initialization - Algorithms with Adaptive Learning Rates - Approximate Second-Order MethodsOptimization Strategies and Meta-Algorithms

Unit 3

Convolution Networks

Convolutional Networks -Operation - Motivation - Pooling - Variants of the Basic Convolution Function -Efficient Convolution Algorithms -Random or Unsupervised Features, Sequence Modeling: Recurrent and Recursive Nets - Unfolding Computational Graphs - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures -Deep Recurrent Networks -Recursive Neural Networks, Applications.

Unit 4

Tabular Solution Methods

Multi-armed Bandits-Dynamic Programming - Monte Carlo Methods -Temporal-Difference Learning -n-step Bootstrapping

Unit 5

Approximate Solution Methods

On-policy Prediction with Approximation -On-policy Control with Approximation –Off

policy Methods with Approximation -Policy Gradient Methods

Course outcome:

- Ability to explain and describe the basics of deep learning and reinforcement techniques
- Ability to investigate different regularization and optimization techniques for training deep neural networks.
- Ability to implement convolution and recurrent neural networks
- Ability to implement and compare various iteration, Monte Carlo temporal-difference reinforcement learning algorithms
- Ability to construct and apply on-policy and off-policy reinforcement learning algorithms with function approximation

Text Book:

1. Ian Goodfellow, YoshuaBengio, and Aaron Courville, "Deep Learning" MIT Press, 2016.
2. Richard S. Sutton and Andrew G. Barto,"Reinforcement Learning: An Introduction" second edition, MIT Press.

Reference Book:

1. CosmaRohillaShalizi, Advanced Data Analysis from an Elementary Point of View, 2015.
2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.

CS-5024	Advanced Soft Computing	L-T-P-C:3-1-0-4

- The course help in understanding the concepts in Soft Computing techniques VIZ Fuzzy systems, Genetic algorithms, Simulated annealing, Ant Colony Optimization and Artificial Neural Networks, to apply these tools in solving problems, to analyze the strengths and weakness of these methods and to choose appropriate Soft Computing technique(s) for a given problem.

Unit 1

FUZZY SET THEORY

Introduction to Soft Computing. Fuzzy sets and relations- operations – composition. Membership functions – features –

Fuzzification - membership value assignments. Defuzzification – Lambda cuts (sets and relations) – Defuzzification to scalars.

Fuzzy Logic – approximate reasoning – different forms of implication. Natural language and Linguistic hedges. Fuzzy Rule-based

systems – graphical techniques for inference. Extension principle and Fuzzy arithmetic.

Case Studies (minimum two) – application of Fuzzy Logic.

Unit 2

OPTIMIZATION

Genetic algorithm – Biological background – Search space – Basic terminologies in GA – a simple GA – General GA – Operators in GA (Encoding, Selection, Crossover – mutation) – stopping conditions – Constraints – Problem solving - The schema theorem –advantages – applications.

Case study - Application of GA. Simulated Annealing: Annealing Schedule, Parameter Selection, Applications.

Case study - Application of SA. Ant Colony Optimization: Ant Foraging Behavior, artificial ants and minimum cost paths, ACO Metaheuristic, ACO algorithm for

TSP problem, Theoretical considerations, convergence proof, ACO and Model based search. ACO optimization for subset problem

Unit 3

NEURAL NETWORKS -I

Supervised Learning Neural Networks – Perceptrons - Adaline – BackpropagationMutilayerPerceptrons – Radial Basis Function Networks – Unsupervised Learning Neural Networks – Competitive Learning Networks – Kohonen Self-Organizing Networks.

Case study – Application of ANN.

Unit 4

NEURAL NETWORKS -II

Adaptive Resonance Theory – Introduction – ART 1 – ART2 – Applications. Basic concepts in Associative memory – BAM.

Extreme Learning Machines - introduction – theory – applications- case study.

Hybrid soft computing systems – ANFIS – concepts and architecture - case study.

Unit 5

DEEP NETWORKS

Introduction to Deep learning – Deep neural networks – concepts. Recurrent neural network - concepts – applications.

Convolutional neural network – concepts – case study based on image classification.

Course outcome:

- Explain concepts in Fuzzy sets, Fuzzy Logic, Genetic Algorithm, Simulated Annealing and Ant Colony Optimization.
- Illustrate how Fuzzy Logic, Simulated annealing, Genetic Algorithm and Ant Colony optimization are used to solve problems.
- Explain concepts in Artificial Neural Networks (MLP, RBFN, KSOM, ART, BAM, ELM, Deep NN, CNN, RNN).
- Illustrate the use of ANN in solving problems.
- Select appropriate Soft Computing technique to solve a problem.
- Solve Engineering problems using Soft Computing techniques.

Text Book:

1. Sivanandam&Deepa, "Principles of Soft Computing", 2nd Edition, Wiley India, 2011
2. T. J. Ross, "Fuzzy Logic with Engineering Applications", 3rd Edition, Wilev, 2014
3. Dorigo Marco, Stützle Thomas, "ANT COLONY OPTIMIZATION", PHI, 2005

Reference Book:

1. Rajasekaran and G A V Pai, " Neural Networks, Fuzzy Logic and Genetic Algorithm", 1st Edn, PHI, 2011

2. D. E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", 1st Edn, Pearson, 2016