# National Institute of Technology Durgapur
# Department of Computer Science & Engineering
## M.Tech Curriculum

### First Semester

| Sl. No. | Sub. Code | Subject | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CS 1001 | Mathematical Concepts in Computer Science | 3-1-0 | 4 |
| 2 | CS 1002 | Advanced Algorithms | 3-1-0 | 4 |
| 3 | CS 1003 | Advanced Software Engineering | 3-1-0 | 4 |
| 4 | | Elective-I | 3-1-0 | 4 |
| 5 | | Elective-II | 3-1-0 | 4 |
| 6 | CS1051 | Software Engineering Laboratory | 0-0-4 | 2 |
| 7 | CS1052 | Modeling and Simulation Laboratory | 0-0-4 | 2 |
| **TOTAL** | | | | **24** |

### Second Semester

| Sl. No. | Sub. Code | Subject | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CS 2001 | Advanced Database Management System | 3-1-0 | 4 |
| 2 | CS 2002 | Distributed System | 3-1-0 | 4 |
| 3 | CS 2003 | Advanced Computer Architecture | 3-1-0 | 4 |
| 4 | | Elective-III | 3-1-0 | 4 |
| 5 | | Elective-IV | 3-1-0 | 4 |
| 6 | CS2051 | Network and Distributed System Laboratory | 0-0-4 | 2 |
| 7 | CS2052 | Seminar – I (Non-Project) | 0-0-2 | 1 |
| 8 | CS2053 | Project - I | 0-0-2 | 1 |
| **TOTAL** | | | | **24** |

### Third Semester

| Sl. No. | Sub. Code | Subject | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CS3051 | Project - II | | 11 |
| 2 | CS3052 | Project Seminar – I | | 2 |
| **TOTAL** | | | | **13** |

### Fourth Semester

| Sl. No. | Sub. Code | Subject | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CS4051 | Project - III | | 11 |
| 2 | CS4052 | Project Seminar – II & Viva-Voce | | 3 |
| **TOTAL** | | | | **14** |
| **Total Program Credit** | | | | **75** |

## <u>LIST OF ELECTIVES</u>

**Elective –I**

| | | | |
|---|---|---|---|
| CS9011 | CAD for VLSI | 3-1-0 | 4 |
| CS9021 | Soft Computing | 3-1-0 | 4 |
| CS9022 | Pattern Recognition | 3-1-0 | 4 |
| CS9023 | Data Warehousing and Data Mining | 3-1-0 | 4 |
| CS9024 | Computer Vision | 3-1-0 | 4 |
| CS9025 | Optical Networks | 3-1-0 | 4 |
| CS9033 | Advanced Artificial Intelligence | 3-1-0 | 4 |
| CS9040 | Advanced Graph Theory | 3-1-0 | 4 |
| CS9045 | Simulation and Analysis of Communication Networks | 3-1-0 | 4 |
| CS9047 | Digital Image Processing | 3-1-0 | 4 |
| CS9067 | Randomized Algorithms | 3-1-0 | 4 |
| CS9069 | Convex Optimization | 3-1-0 | 4 |
| CS9070 | Machine Learning | 3-1-0 | 4 |
| CS9071 | Fundamentals of Cryptography | 3-1-0 | 4 |
| CS9074 | Data Analytics | 3-1-0 | 4 |

**Elective-II**

| | | | |
|---|---|---|---|
| CS9013 | Wireless Networks & Mobile Computing | 3-1-0 | 4 |
| CS9014 | Theory of Computation | 3-1-0 | 4 |
| CS9016 | Computational Geometry | 3-1-0 | 4 |
| CS9017 | Information & Coding Theory | 3-1-0 | 4 |
| CS9026 | Peer to peer Networks | 3-1-0 | 4 |
| CS9027 | Adhoc Networks | 3-1-0 | 4 |
| CS9028 | Sensor Networks | 3-1-0 | 4 |
| CS9029 | Embedded System | 3-1-0 | 4 |
| CS9030 | High Performance Computing | 3-1-0 | 4 |
| CS9031 | Complex network | 3-1-0 | 4 |
| CS9032 | Testing and verification Of VLSI Circuits | 3-1-0 | 4 |
| CS9044 | Computational Bio-Informatics | 3-1-0 | 4 |
| CS9049 | Adaptive Signal Processing | 3-1-0 | 4 |
| CS9050 | Swam Robotics Design And Simulation | 3-1-0 | 4 |
| CS9054 | Bio-Medical Signal And Image Processing | 3-1-0 | 4 |
| CS9057 | Cloud Computing | 3-1-0 | 4 |
| CS9062 | Introduction to Human Activity Recognition | 3-1-0 | 4 |
| CS9063 | Human Computer Interaction | 3-1-0 | 4 |
| CS9084 | Bioinformatics | 3-1-0 | 4 |
| CS9085 | Expert System | 3-1-0 | 4 |

**Elective–III**

| | | | |
|---|---|---|---|
| CS9015 | Web Design and Web Mining | 3-1-0 | 4 |
| CS9034 | Software Testing and Verification | 3-1-0 | 4 |
| CS9035 | Principles of Programming Language | 3-1-0 | 4 |
| CS9036 | Fault Tolerance System | 3-1-0 | 4 |
| CS9039 | Computer Graphics and Application | 3-1-0 | 4 |
| CS9046 | Agent Based Computing | 3-1-0 | 4 |
| CS9051 | Knowledge Management Application | 3-1-0 | 4 |
| CS9052 | Internet of Things | 3-1-0 | 4 |
| CS9053 | Computational Social Science | 3-1-0 | 4 |
| CS9055 | Semantic Web and Linked Data Engineering | 3-1-0 | 4 |
| CS9059 | Software Quality | 3-1-0 | 4 |
| CS9060 | Knowledge Based System Engineering | 3-1-0 | 4 |
| CS9064 | Management Information Systems | 3-1-0 | 4 |
| CS9068 | Optimization Techniques and Decision Procedures for Computer-Aided Design and Verification | 3-1-0 | 4 |

**Elective–IV**

| | | | |
|---|---|---|---|
| CS9018 | Cryptology and Cryptanalysis | 3-1-0 | 4 |
| CS9019 | Network Security | 3-1-0 | 4 |
| CS9041 | Information Security and Trust management | 3-1-0 | 4 |
| CS9042 | Game Theory and its Applications | 3-1-0 | 4 |
| CS9056 | Biometrics | 3-1-0 | 4 |
| CS9058 | Information And System Security | 3-1-0 | 4 |
| CS9061 | Secure Software Development | 3-1-0 | 4 |
| CS9065 | System Analysis and Design | 3-1-0 | 4 |
| CS9072 | Secure Multiparty Computation | 3-1-0 | 4 |
| CS9073 | Advanced Topics in Cryptography | 3-1-0 | 4 |
| CS9075 | Security Engineering for Business Computing | 3-1-0 | 4 |
| CS9076 | Machine Learning and Its Applications in Cyber Security | 3-1-0 | 4 |
| CS9077 | Computer Crime Investigation and Cyber Forensic | 3-1-0 | 4 |
| CS9078 | Cyber Law and Rights in the Digital Age | 3-1-0 | 4 |
| CS9079 | Wireless & Mobile Computing | 3-1-0 | 4 |
| CS9080 | Information Theory & Coding | 3-1-0 | 4 |
| CS9081 | Web Mining and Analytics | 3-1-0 | 4 |
| CS9082 | Internet of Things Security | 3-1-0 | 4 |
| CS9083 | Hardware Security and Its Applications | 3-1-0 | 4 |

M.Tech Computer Science offers six (6) core papers and four (4) elective papers. The electives are divided into four Pools of Electives.

- Elective- I should be opt from the list of Pool –I.
- Elective –II should be opt either from Pool-II, Pool-III or Pool-IV.
- Elective –III and IV should be opt from any one of the four Pools (i.e. Pool-I, II, III or IV).

## Detailed Syllabus of the Course

<table>
<tr><td colspan="9">Department of Computer Science & Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS1001</td><td>Mathematical Concepts in Computer Science</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CSC301 (Discrete Mathematics)</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• To help the student to gain the ability to use some of the fundamental methods of discrete mathematics in Computer Science.<br>• To use these methods in a variety of sub-fields of computer science ranging from complexity theory, algorithms, machine learning, computer networks etc.<br>• To use logical notation to define and reason mathematically about the fundamental data types and structures (such as numbers, sets) used in computer algorithms and systems<br>• To construct complete formal proofs/arguments for a mathematical statement (theorem)</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Logic Formulas: Propositional Logic in Computer Programs, Equivalence, and Validity, The Algebra of Propositions, SAT problems, Predicate formulas. (4)<br>Proof Techniques: Non-constructive proof, proof by contradiction, contrapositive proofs, proof of necessity and sufficiency; Mathematical Induction- Strong Induction, well ordering principle, pigeon-hole principle - Ramsey number. (5)<br>Set Theory, Relations, Functions- Fundamental of Set theory, Size of a set: Finite and infinite sets, countable and uncountable sets, power set theorem, Schroeder-Bernstein theorem. Relations: reflexive, symmetric, transitive, ant symmetric, Equivalence, partial ordering relations, equivalence relations, Partial Order, Lattice, Partial Order, Lattice, Hasse Diagram, Functions- Surjection, Injection, Bijection, Composition of Function, Asymptotic notations: big-Oh, small-oh, Theta, Omega. (9)<br>Recurrence Relations and Generating Functions: Recurrence Relations--Introduction to recurrence relation, Linear recurrence with constant coefficients, Solutions of recurrence relations, Master Methods and Josephus problem and its solution. Generating Functions - Counting with Generating Functions, Partial Fractions, Solving Linear Recurrences. (6)<br>Introduction to counting: Basic counting techniques - inclusion and exclusion, permutation, combination, summations. Catalan Number - Stack Permutation, Valid parenthesization, number of monotonic Manhattan paths, Convex polygon triangulation. (7)<br>Linear Algebra: Matrices and determinants; Vector spaces; Linear transformations and their matrices; Eigenvalues and Eigen vectors; Characteristic polynomial and minimal polynomial. (10)<br>Linear Programming: Simplex algorithm, Duality, LP rounding and vertex cover, randomized LP rounding. (5)<br>Graph Theory: basic definitions, complement of a graph, clique, independent set, bipartite graph, chromatic number, graph isomorphism, sub graph, induced sub graph, path, cycle, walk, Petersen graph, connected component, Degree Sequence, Graphic sequence, Adjacency matrix and number of walks, Shortest Path in a weighted graph, BFS, DFS, Bipartite graphs and odd cycles, Strongly connected component, Eulerain trail, Directed graph, Tree, Radius, Diameter, Centre of a graph MST; Edge subdivision, Planarity, K(3,3) and K(5), Kuratowski's theorem (statement), Euler's theorem, Chromatic number, Minimum Vertex Cover and Maximum Independent Set, Hamiltonian path and cycle, Introduction to Matching, perfect matching.(10)</td></tr>
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|---|---|
| Text Books, and/or reference material | Text Books:<br>1. C. L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill<br>2. Norman L. Biggs, Discrete Mathematics, Oxford<br>3. Douglas B. West, Introduction to Graph Theory, Prentice Hall, India<br>4. G. Strang, Linear Algebra and Its Applications, Cengage Learning<br>Reference Books:<br>1. Ronald L. Graham, Donald E. Knuth, and O. Patashnik, Concrete Mathematics,<br>Pearson Education |

| Department of Computer Science and Engineering | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 1002 | Advanced Algorithms | PCR | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| Some course on Algorithms and Data structures, Discrete mathematics, Probability. | | CT+EA | | | | | |
| Course Outcomes | • CO1: Can have the efficiency in the complexity analysis of the algorithms.<br>• CO2: Detecting and applying the algorithmic structures in many different fields of engineering.<br>• CO3: Will have the knowledge for state-of-the-art development in the field of algorithms. | | | | | | |
| Topics Covered | Introduction to Algorithm – Motivations, Asymptotic notations, solution to recurrence relations, Amortized running time complexity. (6)<br>Parallel Algorithms – **(a)** Motivation for parallel algorithm, Parallel addition, Parallel implementation of Quick sort, Energy complexity of parallel algorithms - Derivation of asymptotic energy complexities of parallel algorithms, Analysis of parallel algorithms. **(b)** Selection problem - Sequential selection, Parallel selection on EREW SM SIMD machine and its analysis. **(c)** Searching problem - Parallel search - implementation of K-ary search and its analysis. **(d)** Graph algorithms - Parallel formulation for finding Connected components of a graph, finding Maximum Independent Set of a graph- parallel implementation. (12)<br>Advanced Data Structures – van Emde Boas Trees, Augmented Data structure, Heavy hitters' problem- Bloom filters and Count-Min sketch. (6)<br>Network Flow **-** Flow networks, augmenting paths, Ford- Fulkerson Algorithm, Edmonds - Karp algorithm, Max flow min-cut theorem, Push-relabel algorithm, Maximum bipartite matching, Some applications of network flow. (6)<br>Randomized Algorithm**-** Las Vegas and Monte Carlo algorithms, five essential mathematical tools for Randomized algorithms: Linearity of expectation, Markov inequality, Chebyshev's inequality, Chernoff bound, and Union bound with examples to Randomized algorithm design. Examples and analysis of: Randomized Quick Sort, Min Cut problem, and Skip list. (6)<br>Online Algorithms**:** Overview, Online scheduling and online Steiner tree, Online Bipartite matching, Online learning and multiplicative weights algorithm. (6)<br>NP**-** Completeness - Classes of P, NP, NP-Hard, NP-Complete, Co-NP; Reduction; Cook's Theorem, SAT, NP-Completeness proof of different problems: CLIQUE, VERTEX COVER, INDEPENDENT SET, SET COVER. (6)<br>Approximation Algorithms - Constant factor approximation algorithm: VERTEX COVER and TSP; Christofides algorithm on TSP with 1.5 approximation factor; SET-COVER problem with log n factor approximation algorithm; PTAS and FPTAS, Linear programs and approximation algorithms. (8) | | | | | | | |
| Text Books, and/or reference | **Text Books:**<br>1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd Edition, Cambridge University press, Cambridge, MA, 1995.<br>2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford | | | | | | |

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| material | Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009, ISBN: 9780262033848.<br>3. S. G. Akl, the Design and Analysis of Parallel Algorithms, Prentice-Hall, 1989.<br>4. M. J. Quinn, Designing Efficient Algorithms for Parallel Computers, McGraw Hill Higher Education, 1987, ISBN: 978-0070510715.<br>5. J. Kleinberg and E. Tardos, Algorithm Design, Pearson.<br>6. D. V. Williamson and D. B. Shmoys, the Design of Approximation Algorithms, Cambridge University Press.<br>7. S. Arora and B. Barak, Computational Complexity: A Modern Approach, Cambridge University Press.<br>**Reference Book/Lecture Notes:**<br>1. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific**,** July 2008.<br>2. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press.<br>3. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016.<br>4. T. Roughgarden, CS168: Modern Algorithmic Toolbox (Stanford University), 2017. |

| **Department of Computer Science & Engineering** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 1003 | Advanced Software Engineering | PCR | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| CS 01 | | CT+EA | | | | | |
| Course Outcomes | • CO1: To explain and exemplify advanced concepts of Software Engineering.<br>• CO2: To learn various design principle in modelling a software and development techniques which adheres to the standard benchmarks.<br>• CO3: To evaluate the suitability of different design alternatives based on object-oriented design principles, and identify design flaws in programs<br>• CO4: To identify verification and validation methods in a software engineering project<br>• CO5: To analyze and apply project management techniques for a case study.<br>• CO6: To use a modelling language as a means to communicate realistic problems and their solutions. | | | | | | |

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| Topics Covered | Review of Software Process, Business Process Engineering, S/W Engineering Paradigm, Software Process Models (linear, incremental, evolutionary, prototyping)- Life Cycle System Development, Prototype, Rapid Application Development, Spiral, Component Based Systems/W process Workflow, Umbrella Activities. (8)<br>Software Requirements Engineering - Requirements Elicitation; Analysis – Information, Functional and Behavioural Analysis; Analysis Modelling (Entity Relationship, Extended Entity Relationship, Control Flow, Data Flow, State Transition Diagram, Petri Net); System Requirement Specification, Decision Tree and Decision Table; Cause-Effect. (8)<br>Design Concepts and Principles, Modular Design – Cohesion, Coupling, Component Design; class and object modelling, design patterns, user interface design, architectural design and Style; Design evaluation; improvement, and refactoring; Enterprise Architecture, Model Driven Architecture, Domain Specific Modelling. (10)<br>Software Testing, Taxonomy of S/W testing, testing boundary, Conditions, structural testing, regression testing, S/W testing strategies, unit testing, integration testing, validation testing, system testing, defect-based testing and debugging. (8)<br>Software Project Management, S/W cost estimation, COCOMO Model, Delphi method, S/W challenges, Line of Codes (LOC) based Metrics, Function point and Feature point estimation, Halstead's Software Metrics; Project scheduling and tracking, defining task set-Defining task network, scheduling earned value analysis-Error tracking-project plan S/W maintenance. (8)<br>Risk management, Software risks, Risk identification, Risk projection, Risk refinement, safety risks and hazard, RMMM plans. (6)<br>Software quality assurance, Quality concepts, The quality movement-software quality<br>Assurance-Reviews-Reliability. (4)<br>Software configuration management, Identification of objects in the software configuration, configuration audit-SCM standards. (4) |
| Text Books, and/or reference material | Text Books:<br>1. R. S. Pressman, "Software Engineering - A practitioner's approach", McGraw Hill International editions.<br>2. Ian Sommerville, "Software Engineering", Pearson Education Asia.<br>Reference Books:<br>1. Pankaj Jalote, "An Integrated Approach to software Engineering", Springer Verlag.<br>2. Rajib Mall, "Fundamentals of Software Engineering", PHI<br>3. James F. Peters and Witold Pedryez, "Software Engineering – An Engineering Approach", John Wiley and Sons, New Delhi. |

| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 2001 | Advanced Database Management Systems | PCR | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| Fundamental of DBMS, Data Structures | | CT+EA | | | | | |
| Course Outcomes | • CO1: Acquire knowledge about the design and application view of DBMS<br>• CO2: Able to analyze query expression, specially importance of query | | | | | | |

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| | optimization<br>• CO3: To learn about design, features and operations in the field of DDBMS, OODBMS and DW<br>• CO4:To learn the concept of using multimedia database as a real-life application |
| Topics Covered | Comparison between different databases: Significance of Databases, Database System Applications, Advantages and Disadvantages of different Database Management systems, Comparison between DBMS, RDBMS, Distributed and Centralized DB, Introduction of various types of index structures: Primary, Secondary, Multilevel, Dynamic multilevel (B-tree and B+- tree).(5)<br><br>Normalization: Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form, The boyce-code normal form (BCNF), Fourth Normal form and fifth normal form, normalization and database design, Denormalization, Loss-less join decomposition, Dependency preservation. (6)<br>Transaction processing: Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability, Transaction management in multi-database system, long duration transaction, high-performance transaction system. (5L)<br>Concurrency Control Serializability: Enforcing, Serializability by Locks, Locking Systems with Several, Lock Modes, Architecture for a Locking Scheduler Managing Hierarchies of Database Elements, Concurrency Control by Timestamps, Concurrency Control by Validation, Database recovery management.(5)<br>Query Optimization: Algorithm for Executing Query Operations: External sorting, select operation, join operation, PROJECT and set operation, Aggregate operations, Outer join, Heuristics in Query Optimization, Semantic Query Optimization, Converting Query Tree to Query Evaluation Plan, multiquery optimization and application, Efficient and extensible algorithms for multi-query optimization.(5)<br>Query Execution: Introduction to Physical-Query-Plan Operators, One-Pass Algorithms for Database, Operations, Nested-Loop Joins, Two-Pass Algorithms Based on Sorting, Two-Pass, Algorithms Based on Hashing, Index-Based Algorithms, Buffer Management, Parallel Algorithms for Relational Operations, Using Heuristics in Query Optimization, Basic Algorithms for Executing Query Operations.(5)<br>Distributed Database (DDB): Introduction of DDB, DDBMS architectures, Homogeneous and Heterogeneous databases, Distributed data storage, Advantages of Data Distribution, Disadvantages of Data Distribution Distributed transactions, Commit protocols, Availability, Concurrency control & recovery in distributed databases, Directory systems, Data Replication, Data Fragmentation. Distributed database transparency features, distribution transparency.(5)<br>Object Oriented DBMS(OODBMS): Overview of object: oriented paradigm, OODBMS architectural approaches, Object identity, procedures and encapsulation, Object oriented data model: relationship, identifiers, Basic OODBMS terminology, Inheritance , Basic interface and class structure, Type hierarchies and inheritance, Type extents and persistent programming languages, OODBMS storage issues.(5) XML Query processing: XML query languages: XML-QL, Lorel, Quilt, XQL, XQuery, and Approaches for XML query processing, Query processing on relational structure and storage schema, XML database management system. (5)<br>Data Warehousing: Overview of DW, Multidimensional Data Model, Dimension Modelling, OLAP Operations, Warehouse Schema (Star Schema, Snowflake Schema), Data Warehousing Architecture, Virtual Data, Metadata and Types of Metadata, OLAP Engine, Data Extraction, Data Cleaning, Loading, Refreshing.(8)<br>Database application: Multimedia database, Video database management: storage management for video, video pre-processing for content representation |

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| | and indexing.(2) |
| Text Books, and/or reference material | **Text Books:**<br>1. C. J Date, Pearson Education, "An Introduction to Data Base Systems".<br>2. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, McGraw-Hill, "Database System Concepts".<br>3. Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions. "Distributed Databases Principles & Systems".<br>**Reference Book:**<br>1. RamezElmasri and Shamkant B. Navathe, Addison-Wesley, "Fundamentals of Database Systems", |

| Department of Computer Science & Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 2002 | Distributed Systems | PCR | 4 | 0 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| Operating Systems | | CT+EA | | | | | |

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| Course Outcomes | • CO1: To explain the paradigm of distributed computing.<br>• CO2: To explore various existing and possible architectures of distributed systems.<br>• CO3: To properly appreciate the issues that arise in distributed systems and explore solutions for the problems.<br>• CO4: To fully appreciate the advantages to be obtained from a distributed environment with respect to fault tolerance, load sharing etc. |
| Topics Covered | Introduction to Distributed Systems. Motivations. Design Issues. (5)<br>Clocks in a Distributed System. Synchronization Issues. Logical Clocks. Causal relationships. Vector Clocks. (5)<br>Distributed State Detection. Global State. Consistent Cut. Global State recording algorithm. (4)<br>Termination Detection. Credit based algorithm. Diffusion Computation based algorithm. (4)<br>Distributed Mutual Exclusion. Token based and non-token based algorithms. (6)<br>Deadlocks in Distributed Systems. Resource allocation Models. Deadlock Prevention. Deadlock Avoidance – Safe states. Deadlock detection and Correction. Phantom Deadlocks. Centralized, Distributed and Hierarchical deadlock detection algorithms. (10)<br>Fault Tolerance. Classes of Faults. Byzantine faults and Agreement Protocols. Distributed Commit Protocols. 2-phase commit. 3-phase commit. Election Algorithms. Bully algorithm. Ring topology algorithm. Fault recovery. Backward and Forward recovery. Log based recovery. Checkpoints. Shadow paging. Data Replication. Quorum Algorithms. (12)<br>Distributed File systems. Mechanisms. Stateful and Stateless servers. Scalability. Naming and Name Servers. (5)<br>Distributed Scheduling. Load Balancing. Load Estimation. Stability. Process Migration. Remote Procedure Calls. Transparency. Binding. (5) |
| Text Books, and/or reference material | **Text books**<br>1. Advanced Concepts in Operating Systems. Singhal and Sivaratri. McGraw Hill.<br>**Reference Books:**<br>1. Operating Systems: A Concept Based Approach. Dhamdhere. McGraw Hill.<br>2. Distributed Operating Systems: Concepts and Design. P. K. Sinha. Prentice Hall.<br>3. Distributed Operating Systems. A. Tanenbaum. Pearson Education.<br>4. Distributed Systems: Concepts and Design. Coulouris et.al. Pearson Education. |

<table>
<tr><td colspan="8">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 2003</td><td>Advanced Computer Architecture</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Digital Logic design, Computer Organization, Computer Architecture</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To know about the classes of computers, and new trends and developments in computer architecture<br>• CO2: To acquire knowledge about the various architectural concepts that may be applied to optimize and enhance the classical Von Neumann architecture into high performance computing systems.<br>• CO3: To learn the basic design procedure for different levels of parallelism.<br>• CO4: To learn the design issues relating to the architectural options.<br>• CO5: To know the challenges faced in the implementation of these high performance system.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">OVERVIEW OF VON NEUMANN ARCHITECTURE: Instruction set architecture; The Arithmetic and Logic Unit, The Control Unit, Memory and I/O devices and their interfacing to the CPU; Measuring and reporting performance; CISC and RISC processors. (4)<br>PIPELINING: Pipelining fundamentals, Linear and Nonlinear Pipeline Processors, Arithmetic and instruction pipelining, Pipeline hazards, Techniques for overcoming or reducing the effects of various hazards, superscalar and super pipelined and VLIW architectures. (8)<br>INSTRUCTION –LEVEL PARALLELISM (ILP): Concepts and challenges; Techniques for increasing ILP - Basic Compiler Techniques for exposing ILP; Reducing Branch costs with prediction; Overcoming Data hazards with Dynamic scheduling; Hardware-based speculation, Advanced Techniques for instruction delivery and Speculation. (10)<br>MULTIPROCESSORS ARCHITECTURES: Introduction; Taxonomy of parallel architectures, Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture. (8)<br>MEMORY HIERARCHY DESIGN: Introduction; Cache performance; Cache Optimizations, cache coherence, cache coherence protocols – snoop based and directory based protocols, Advanced optimizations of Cache performance, Memory technology and optimizations, Virtual memory, Protection: Virtual memory and virtual machines. (12)<br>INTERCONNECTION NETWORKS: Topology, Different interconnection Networks, Routing Mechanism. (4)<br>Non von Neumann architectures: data flow computers, systolic architectures. (4)<br>Introduction to Open MPI/CUDA Tutorials**.** (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. Computer Architecture, A Quantitative Approach – John L. Hennessey and David A. Patterson; 4th edition, Morgan Kaufmann.<br>2. Advanced Computer Architecture Parallelism, Scalability, Programmability – Kai Hwang; Tata Mc-Graw Hill.<br>Reference Books:<br>1. Computer architecture and parallel processing – Kai Hwang and FayéAlayé Briggs; McGraw-Hill.<br>2. Parallel Computer Architecture, a Hardware / Software Approach – David E. Culler, Jaswinder Pal Singh, Anoop Gupta; Morgan Kaufman.<br>3. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw-Hill.<br>4. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House.<br>5. NPTEL/MOOC Courses materials</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS9011</td><td>CAD for VLSI</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Digital Electronics, Computer Organization.</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To visit the various stages of the VLSI design cycle and appreciate the role of automation therein.<br>• CO2: To appreciate how High-Level Synthesis converts an HDL code into an architecture level design.<br>• CO3: To discuss the algorithmic approach to physical design.<br>• CO4: To emphasize the importance to testability measures in the design.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">VLSI Design cycle. Design styles. System packaging styles. Fabrication of VLSI devices. Design rules-overview. (5)<br>HLS: Scheduling in High Level Synthesis. ASAP and ALAP schedules. Time constrained and Resource constrained scheduling. (6)<br><br>HLS: Allocation and Binding. Data path Architectures and Allocation tasks.(6)<br>Partitioning. Clustering techniques. Group Migration algorithms. (5)<br>Floor planning. Constraint based Floor planning. Rectangular Dualization. Hierarchical Tree based methods. Simulated Evolution approaches. Timing Driven floor planning.(6)<br>Placement. Simulation based placement algorithms. Partitioning based placement algorithms, Cluster Growth.(6)<br>Global Routing. Maze Routing algorithms. Line probe algorithms. Shortest Path based algorithms. Steiner’s Tree based algorithms.(6)<br>Detailed Routing. Channel Routing Algorithms. Switchbox Routing. Over-the-cell routing. Clock and Power Routing.(6)<br>Design for testability. Fault testing. Ad-hoc and structured DFT techniques.(10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books<br>1. Algorithms for VLSI Physical Design Automation. N. A. Sherwani. Kluwer Academic Publishers.<br>2. High-Level Synthesis: Introduction to Chip and System Design. Gajski et. al. Kluwer Academic Publishers.<br>3. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications<br><br>Reference Books<br>1. VLSI Physical Design Automation. Sadiq M. Sait and Habib Youssef. Kluwer Academic Publishers.<br>2. Algorithms for VLSI Design Automation. Sabih H. Gerez. Wiley India.<br>3. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.</td></tr>
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Department of Computer Science and Engineering

| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
|---|---|---|---|---|---|---|---|
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9016 | Computational Geometry | PEL | 3 | 1 | 0 | 4 | 4 |

| Pre-requisites | Course Assessment methods (Continuous (CT) and end assessment (EA)) |
|---|---|
| Design and analysis of algorithm | CT+EA |

**Course Outcomes**

- CO1: To design 'new' geometric algorithms.
- CO2: To map problems to computational geometric problems.
- CO3: To solve a wide range of practical problems in a variety fields such as graphics, robotics, databases, sensor network
- CO4: To read and understand algorithms published in journals.

**Topics Covered**

**Computational Geometry Introduction**: Historical perspectives, Geometric preliminaries, Convex Hull, Algorithms to find the Convex Hull of a point set in 2D plane: Graham's Scan Algorithm, Divide and Conquer algorithm, Output sensitive algorithm: Jarvis's March Algorithm, Timothy Chan's Algorithm; Lower bound analysis for Convex Hull Algorithm, Application Domains. (7)

**Line Segment Intersection**: Line Segment Intersection, The Doubly-Connected Edge List, Computing the Overlay of Two Subdivisions, Boolean Operations. (4)

**Polygon Triangulation**: Guarding and Triangulations, Area of a simple polygon, Counting the number of triangulations in a convex polygon, Art Gallery Theorem, Monotone Polygon, partitioning a Polygon into Monotone Pieces, Triangulating a Monotone Polygon, Hardness proof of Art Gallery theorem. (8)

Computing the Minimum Enclosing Disk of a point set & its application; Diameter of a point set. (4)

**Orthogonal Range Searching**: 1-Dimensional Range Searching, Kd Trees, Range Trees, Higher-Dimensional Range Trees, Fractional Cascading. (6)

**Point Location**: Point Location and Trapezoidal Maps, A Randomized Incremental Algorithm to compute a Trapezoidal Map and a Search structure, Kirkpatrick's planar point location problem. (7)

**Voronoi Diagram and Delaunay Triangulation:** Definition and Basic Properties of Voronoi Diagram, Computing the Voronoi Diagram: Fortune Sweep Algorithm, Divide and Conquer Algorithm. Closest pair Problems. Application of voronoi diagrams, Triangulations of Planar Point Sets, The Delaunay Triangulation, Computing the Delaunay Triangulation. (8)

**Arrangements and Duality:** Arrangement of lines, Zone theorem, Duality, Application of arrangements and duality, Ham Sandwich Cut. (4)

**Geometric Data Structure**: Interval Trees, Priority Search Trees, Segment Trees. (4)

**Visibility graphs**: Shortest path for a point Robot, computing the visibility graph. (4)

**Text Books, and/or reference material**


**Text Books:**

1. Marc van Kreveld, Mark Overmars, Otfried Cheong, **Computational Geometry: Algorithms and Applications**, Third Edition, Springer Verlag
2. Franco P. Preparata and Michael Ian Shamos, Computational **Geometry- An Introduction**, Springer Verlag
3. Joseph O' Rourke, **Computational Geometry in C**, Cambridge University Press

**Reference Books:**

1. Lecture notes on Computational geometry by David Mount

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS9017</td><td>Information & Coding Theory</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Probability and statistics, Abstract Algebra, Calculus</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understand the concepts Information Theory<br>• CO2: Understand the application of Information Theory to Source Coding and Data Compression<br>• CO3:Understand the methods of source coding and data compression<br>• CO4: Understand the concept of channel coding and error correction techniques</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Information Theory: Introduction, mathematical measure of information, average and mutual information and entropy. (6)<br>Source Coding and Data Compression: Source coding theorem, Kraft inequality, properties of prefix codes, Shannon-Fano coding, Huffman coding, Lempel-Ziv codes, arithmetic coding, Rate distortion Theory, Lossless Predictive Coding, Lossy Predictive Coding, DPCM. (14)<br>Channel Capacity: Discrete memory less channel model, binary symmetric channels and channel capacity, entropy rate and channel coding theorem, information capacity theorem, Markov process and sources with memory. (10)<br>Error correction codes: Introduction, basic concepts of linear algebra including group, ring, field, vector space etc. (4)<br>Linear Block Codes: Definition, encoding and decoding of linear codes, generator matrix, error detection and correction, perfect codes, Hamming codes. (6)<br>Cyclic codes: Definition, encoding and decoding, cyclic redundancy check. (3)<br>Convolution codes: Encoding convolutional codes, generator matrices for convolutional codes, generator polynomials and graphical representation for convolutional codes. Viterbi decoder. (5)<br>Bose-Chowdhury-Hoquenghem codes: Definition and construction of BCH codes, decoding SEC and DEC binary BCH codes, Reed Solomon codes. (4)<br>Trellis coded modulation: Introduction, the concept of coded modulation, signal mapping and set partitioning, TCM decoder. (4)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books<br>1. Information Theory and Coding. N. Abramson. McGraw Hill<br>2. Elements of Information Theory. Thomas M. Cover and Joy A. Thomas. Wiley.<br>3. Error Control Coding. Shu Lin and Daniel J. Costello. Prentice Hall.<br>4. Coding Techniques. Graham Wade. PALGRAVE.<br>Reference books<br>1. The theory of information and coding. R. J. McEliece. Cambridge.<br>2. Error Control Coding: From Theory to Practice. Peter Sweeney. John Wiley & Sons.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS9021</td><td>Soft Computing</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CS1001</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7"><ul><li>To familiarize with neural networks and learning methods for neural networks;</li><li>To introduce basics of genetic algorithms and their applications in optimization and planning;</li><li>To introduce the ideas of fuzzy sets, fuzzy logic and fuzzy inference system;</li><li>To introduce students’ tools and techniques of Soft Computing;</li><li>To develop skills thorough understanding of the theoretical and practical aspects of Soft Computing.</li></ul></td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Soft Computing: Hard Computing, Soft Computing, Hybrid Computing, Optimization and Some Traditional Methods.(2)<br>Fuzzy Logic: Overview of Crisp Sets, Fuzzy sets, Representation of fuzzy sets, membership functions, Basic operations on fuzzy sets, Properties of fuzzy sets, Extension principles, Fuzzy and Crisp relations, Operations on Fuzzy Relations, Fuzzy Relation Equations. (5)<br>Membership Function, Fuzzification and Defuzzification: Features of membership functions, methods of fuzzifications, defuzzification methods.(3)<br>Fuzzy Measures and Fuzzy Arithmetic: Basis of fuzzy measures, measure of fuzziness, Fuzzy integrals, Fuzzy arithmetic. (4)<br>Fuzzy Rules & Approximate Reasoning: Fuzzy if-then rules: M-A and TSK Rules, Fuzzy Inference /Approximate Reasoning, Applications: Pattern Recognition, Image Processing and Controller. (5)<br>Neural Networks (Introduction & Architecture): Introduction of neural networks: Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Learning methods; perception and convergence rule. (6)<br>Neural Networks (Back propagation networks): Architecture: perceptron model: single layer and multilayer perceptron, back propagation learning, factors affecting back propagation training, RBF networks, Hopfield network, self-organizing feature maps, Applications of ANN. (8)<br>Recurrent Neural Networks: Feedback backpropagation networks, Fully recurrent networks, reinforcement learning. (6)<br>Genetic Algorithm: Evolutionary Computing, Basic concepts and working principle of simple GA (SGA), Genetic Operators: Selection, Crossover and Mutation, flow chart of SGA, Encoding & Decoding, Population Initialization, Objective/fitness Function, Applications: TSP. (6)<br>Multi-objective Genetic Algorithm (MOGA): Conflicting objectives, Objective space and variable space, Domination, Pareto front, Pareto Set, NSGA-II: Non-domination Sorting, Crowding distance operator. (8)<br>Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.(3)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. David E. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Addison-Wesley Publishing Company.<br>2. Satish Kumar, “Neural Networks”, Tata Mc. Graw Hill.<br>3. Timothy J. Ross, “Fuzzy Logic with Engineering Applications”.<br>Reference Books:<br>1. Lin Ching Tai and Lee C S George, Neural Fuzzy Systems: A Neuro-Fuzzy Synergism to Intelligent Systems, Prentice-Hall, 1996.<br>2. George Klir and Bo Yuan, “Fuzzy sets and Fuzzy logic”, Prentice Hall of India.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9022</td><td colspan="2">Pattern Recognition</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">Artificial Intelligence</td><td colspan="6">CE+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7"><ul><li>CO1: Idea about Pattern and Pattern Class, Design of a Pattern Recognition System</li><li>CO2: Idea of Instar, Outstar, Groups of Instar and Outstar, Different types of Memories.</li><li>CO3: Concept of Feed forward, Feedback and Competitive Learning Network</li><li>CO4: Concept of Complex PR Tasks: RBF, RBF Network for Pattern Classification</li><li>CO5 : Idea of Temporal Pattern Recognition: Concepts</li></ul></td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Pattern and Pattern Class: Design of a Pattern Recognition System, Syntactic and Decision Theoretic Approach. (4)<br>Parametric and Non Parametric Methods. (5)<br>Basics of ANN, Different types of Memories. (5)<br>Pattern Recognition Tasks and Pattern Recognition Problems. (5)<br>FF ANN: Pattern Association Network, Pattern Classification Network. (6)<br>FB ANN: Pattern Association, Pattern Storage, Pattern Environment Storage, Auto association. (8)<br>Competitive Learning Network. (6)<br>Complex PR Tasks: RBF, RBF Network for Pattern Classification. (8)<br>Temporal Pattern Recognition: Concepts, Problems in temporal sequence, Architecture for temporal PR Tasks. (9)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:<ol><li>Pattern Classification – Duda, Hart & Stork – J. Wiley & Sons.</li><li>Artificial Neural Networks – B. Yegnanarayana – PHI</li><li>Neural Networks for Pattern Recognition – C.M. Bishop – Oxford</li></ol>Reference Book:<ol><li>Pattern Recognition – S. Theodoridis, K Koutroumbas - ELSEVIER</li></ol></td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>CS 9023</td><td>Data Warehousing and Data Mining</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">Artificial Intelligence</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Understanding the Concept of Data Warehousing and Data Mining<br>• CO2: Association Rules: Item set, Support, Confidence<br>• CO3: Classification – Pattern: Labelled Pattern, Decision Trees<br>• CO4: To understand the SVM, Generalization Error<br>• CO5: To understand the different types of Clustering Methods<br>• CO6: To understand the detection of different types of outliers and outlier detection.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Data Warehousing: Multidimensional Data Model, Dimension Modelling, OLAP Operations. (5)<br>Data Mining: Different Definitions of Data Mining, KDD vs. Data Mining, Stages of KDD, DBMS vs. DM, AI vs. DM. (5)<br>Association Rules: Item set, Support, Confidence, Problem Decomposition, Frequent Item Set, Maximal Frequent Set, Border Set. (6)<br>Classification – Pattern: Labelled Pattern, Approaches of Classification, Evaluation of Classifiers, Normalized Confusion Matrix. (6)<br>Decision Trees: Inductive Learning, ID3 Program, Algorithm for Building Decision Trees, Advantages of Decision Trees for Classification. (6)<br>Classification (Complex): Support Vector Machine (SVM). (5)<br>Clustering: Partitioned and Hierarchical Clustering, k means Clustering, Fast k Means Clustering, Fuzzy K means Clustering, Hierarchical Clustering. (7)<br>Clustering (Complex): Outlier Detection, Outlier vs. Cluster, Types of Outliers, Outlier Detection Methodologies, Supervised, Unsupervised and Semi supervised detection. (6)<br>Temporal and Spatial Data Mining. (5)<br>Web Mining: Web Mining Techniques. (5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. Data Mining Techniques – Arun K Pujari – Universities Press<br>2. Data Mining – VikramPudi, P. Radha Krishna – Oxford University Press<br>Reference Books:<br>1. Data Mining – J. Han, M. Kamber, J. Pei -- Elesvier<br>2. Data Mining – Hand, Mannila and Smith – PHI</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS9025</td><td colspan="2">Optical Networks</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic Concepts of Computer Networks, and Analysis of Algorithms</td><td colspan="6">CE+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">
• CO1: Define the main possibilities and limitations of optical network technologies;<br>
• CO2: Identify and illustrate the main differences between optical networking and traditional networking<br>
• CO3: Idea about routing and wavelength assignment (RWA), virtual topology design, wavelength rerouting, Traffic grooming in WDM optical network design.<br>
• CO4: Idea about wavelength convertible network.<br>
• CO5: Concept and analyze the benefit of various survivability strategies<br>
• CO6: Idea of multicast routing in optical networks</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">
Introduction: Optical fiber principles, Optical transmission system, Wavelength Division Multiplexing (WDM), Optical Network Architectures, Layers of WDM Optical Network, Different issues in wavelength routed network. (7)<br>
WDM network Elements: Optical line terminals, line amplifiers, OADM, OXC. (4)<br>
Routing and Wavelength Assignment (RWA) algorithms: Route Selection algorithms, Wavelength selection algorithms, Fairness and admission control methods, Distributed control protocols. (7)<br>
Virtual Topology Design: Physical and Virtual topology, Traffic routing over virtual topology, Limitations on virtual topology, Virtual topology problem formulation, and Virtual topology design heuristics: HLDA, MLDA, Link elimination via matching algorithms. (6)<br>
Wavelength Convertible Networks: Need for Wavelength Converters, Wavelength convertible switch architecture, Routing in wavelength convertible network, Performance Evaluation of Convertible network, Converter placement problem, Converter placement problem. (6)<br>
Wavelength Rerouting Algorithm: Benefits of wavelength rerouting, Issues in wavelength rerouting, light path Migration, Rerouting schemes, rerouting algorithms. (6)<br>
Survivability in WDM networks. (6)<br>
Optical Multicast Routing: Multicast routing problem, Node architecture, Network with full splitting and sparse splitting, Multicast tree generation, Source-based tree generation, Virtual source-based tree generation, Steiner-based tree generation. (6)<br>
Traffic Grooming concepts and algorithms: Benefits of traffic grooming, Node architecture, Problem formulation, Different traffic grooming algorithms. (8)</td></tr>
<tr><td colspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:<br>
1. WDM OPTICAL NETWORKS Concepts, Design and algorithms by C. Siva Ram Murthy and Mohan Gurusamy (PHI)<br>
2. OPTICAL NETWORKS by Biswanath Mukherjee (TMH)<br>
3. Optical Networks: A Practical Perspective (3rd Edition) by R. Ramaswami, K. Sivarajan, G. Sasaki (Morgan Kaufmann Publishers)</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9031</td><td>Complex Network</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">CSE 1001</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To explain why a general graph theory course fails to deal with structure and dynamics of large-scale real-world networks<br>• CO2: To introduce different parameters for understanding complex network<br>• CO3: To understand and analyses the structure and dynamics of complex networks<br>• CO4: To understand different growth models<br>• CO5: To study different processes and applications on complex network</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic Concepts related to Social Networks: Small world effect, transitivity and clustering, degree distribution, scale free networks, maximum degree; network resilience; mixing patterns; degree correlations; community structures; network navigation. (8)<br>Centrality measures, Node Popularity, Page Rank algorithm, Spectral Graph Theory. (10)<br>Community Structure Analysis- Basic concepts of network communities, various community finding approaches like Girvan-Newman Algorithm, Spectral Bisection Algorithm, Radicchi Edge Clustering Algorithm (for binary as well as weighted graphs), Wu-Hubermann Algorithm, and Random Walk based Algorithm. (10)<br>Random Graphs-Poisson random graphs, generating functions, emergence of giant component, power-law degree distribution, bipartite graph. (10)<br>Random walk on Graphs- Limitations of page rank, page rank++, HITS, Chinese Whispers, Affinity Propagation algorithm. (10)<br>Processes taking place on Networks- Percolation theory and network resilience, Epidemiological processes. (8)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">TEXT Books:<br>1. Guido Caldarelli, Scale-Free Networks, Oxford University Press, Oxford (2007)<br>2. S. N. Dorogovtsev and J. F. F. Mendes, Evolution of Networks, Oxford University Press, Oxford (2003)<br><br>REFERENCE Books:<br>1. M. E. J. Newman, The structure and function of complex networks, SIAM Review 45, 167-256 (2003).<br>2. R. Albert and A. L. Barabasi Statistical mechanics of complex networks. Rev. Mod. Phys., Vol. 74, No. 1, January 2002.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS9032</td><td>Testing of Digital Circuits</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Digital Electronics, Computer organization</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To explain and exemplify basic and advanced concepts of Testing and Verification of Digital Circuits.<br>• CO2: To understand fault modeling and test generation<br>• CO3: To fully appreciate the need for testability measures in the design stage of circuits.<br>• CO4: To understand the use of formal models for verification of the circuit specs.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to VLSI testing and verification. Logic and Event Driven Simulation. Delay Models.(8)<br>Fault Modelling. Single Stuck-at Fault model. Fault Collapsing. Fault Equivalence. Fault Domination. Checkpoint Theorem. (8)<br>Fault Simulation. Serial, Parallel, Deductive and Concurrent.(4)<br>Test Generation. Boolean Difference Method. D-Algorithm. PODEM. FAN. (8)<br>Testability Analysis. (4)<br>Design for Testability. Ad hoc approaches. Scan based Design. Random Scan. Scan FF design. LSSD. Scan-Hold FF.(6)<br>Built-in Self-Test. Pseudo-Random Pattern Generation. LFSR.(8)<br>PLA Testing. (5)<br>Memory testing.(5)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books<br>5. Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits. Bushnell and Agrawal. Kluwer Academic Publishers.<br>6. Digital Systems Testing and Testable Design. Abramovici et.al. Jaico Publications.<br>7. Logic in Computer Science. Huth and Ryan. CambridgeUniversity Press.<br>Reference Books<br>3. Model Checking. Clarke et. al. MIT Press.<br>4. VLSI Test Principles and Architectures. LT Wang et.al. Morgan Kaufman.</td></tr>
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<table>
<tr><td colspan="9">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9040</td><td colspan="2">Advanced Graph Theory</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Discrete mathematics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: Students would be able to reproduce the proofs of some fundamental statements on graphs;<br>• CO2: Students would be able to solve new graph problems<br>• CO3: Students can use a combination of theoretical knowledge and independent mathematical thinking in creative investigation of computer science applications<br>• CO4: Students can explore knowledge of the graph theory to solve the technology driven and research oriented problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Preliminaries: Graphs, isomorphism, auto morphism, components, sub-graphs, degree, operations on graphs, radius, diameter, bipartite graph, Operations on graph: deletion of vertex/edge, fusion, union, intersection, ring sum, decomposition, join, Cartesian product, complement. Self-complementary graphs, circuits. (8)<br>Connected graphs and shortest paths: Walks, trails, paths, connected graphs, distance, cut-vertices, cut-edges, connectivity: edge and vertex connectivity, relationship between edge and vertex connectivity, k-connected graph, Menger's theorem, separable graph, blocks, block-cut vertex tree, block tree, cut vertex tree,1-isomorphism, 2-isomorphism, topological ordering. (12)<br>Trees: Characterizations, number of trees, minimum spanning trees, Distance between spanning tree of a connected graph, eccentricity, Centre(s) of trees and connected graph, diameter of tree and connected graph, nullity of tree, labelled graph. (5)<br>Planarity: Planar graph, Kuratowski's theorem, Euler's formula, Detection of planarity, duality, uniqueness of duality, Homomorphism: subdivision, merging, planarity detection using homeomorphism graphs, five color and four-color problem. (8)<br>Covering, Independent sets, Dominating Set, Matching: Basic concepts, vertex and edge covering, minimal covering, independent set, maximal independent set, relationship between covering and independent set, theorems, dominating set, MDS, CDS, matching in bipartite graphs, perfect matching, maximal matching, minimum matching, Hall's theorem. (9)<br>Factorization: Factor, 1-factor, 2-factor Tutte's theorem. (4)<br>Vertex coloring: Chromatic number and cliques, greedy coloring algorithm, Brook's theorem, chromatic partition, Uniquely colourable graph. (3)<br>Edge coloring: Gupta-Vizingtheorem, coloredge, equitable edge-coloring. (2)<br>Line Graph: Properties and proof. (3)<br>Eulerain graphs: Characterization, Arbitrarily traceable graph, Fleury's algorithm. (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:<br>1Introduction to Graph Theory- D.B.West<br>2. Advanced Graph Theory- R.Diestel<br>3. Graphs - an Introductory Approach- Wilson and Watkins<br>Reference Books:<br>1. Graph Theory- N. Deo<br>2. An Introduction to Graph Theory - S. Pirzaha</td></tr>
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<table>
<tr><td colspan="9">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>CS 9042</td><td>Game Theory and its Applications</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Some course on Algorithms, Data structures, Discrete Mathematics, and Probability.</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Can have the efficiency to act in a strategic situation.<br>• CO2: Can analyses the strategic interactions among agents.<br>• CO3: Can understand modern state of the art in Game Theory and its applications.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction. (2)<br>Non-Cooperative Game Theory: Introduction to Game Theory, Extensive Form Games, Strategic Form Games, Dominant Strategy Equilibrium, Pure Strategy Nash Equilibrium, Mixed Strategy Nash Equilibrium, Sperner's Lemma, Fixed Point Theorem and Existence of Nash Equilibrium, Computation of Nash Equilibrium, Complexity of Computing Nash Equilibrium, Matrix Games (Two Players Zero Sum Games), Bayesian Games, Sub game Perfect Equilibrium. (12)<br>Mechanism Design without Money: One sided and two-sided matching with strict preferences, Voting theory, and Participatory democracy. (6)<br>Mechanism Design with Money: Auction basics, sponsored search auctions, Revenue optimal auctions, VCG Mechanisms. (6)<br>Cooperative Game Theory: Correlated Strategies and Correlated Equilibrium, Two Person Bargaining Problem, Coalitional Games, The Core, and The Shapley Value. (4)<br>Repeated Games and its Applications. (4)<br>Applications: Incentive Study in - P2P Networks, Crowdsourcing, Digital currency, Social networks, Reputation Systems. (10)<br>Some Special Topics - Fair Division, Price of Anarchy, scoring rules, Hierarchy of equilibrium, Learning in Auction, Synergies between Machine Learning & Game Theory. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani. Algorithmic Game Theory. Cambridge University Press, New York, NY, USA, 2007, ISSN: 978-0521872829.<br>2. M. Maschler, E. Solan, and S. Zamir. Game Theory, Cambridge University Press; 1st Edition, ISSN: 978-1107005488, 2013.<br>3. Y. Narahari. Game Theory and Mechanism Design. World Scientific Publishing Company Pte. Limited, 2014, ISSN: 978-9814525046.<br>4. T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge University Press, 2016, ISSN: 978-1316624791.<br>Reference Book/Lecture Notes:<br>1. T. Roughgarden, CS364A: Algorithmic Game Theory Course (Stanford University), 2013.<br>2. T. Roughgarden, CS269I: Incentives in Computer Science Course (Stanford University), 2016.<br>3. S. Barman and Y. Narahari, E1:254 Game Theory Course (IISc Bangalore), 2012.</td></tr>
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| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9047 | Digital Image Processing | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| NIL | | CT+EA | | | | | |
| Course Outcomes | • CO1: Acquire knowledge about image acquisition and camera basics<br>• CO2: To learn the basic algorithms on filtering, quality metrics, segmentation<br>• CO3: To learn about compression and color image processing,<br>• CO4: Development of image processing programs using ImageJ and Python | | | | | | |
| Topics Covered | Introduction, Image acquisition process, image sensors, camera basics (6)<br>Transform functions, Histogram, spatial and frequency filtering (10)<br>Redundancy, compression models, coding methods (10)<br>Point, Line, edge detection, thresholding, region based segmentation (10)<br>Colour models, colour image processing, segmentation and compression using colours (10)<br>Introduction to Image Processing using ImageJ and Python, Image databases (10) | | | | | | |
| Text Books, and/or reference material | Text Books:<br>1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods,<br>2. Fundamentals of Digital Image Processing by Anil K Jain<br>Reference Book:<br>3. Digital Image Processing by William K Pratt | | | | | | |

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|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS9049 | Adaptive Signal Processing | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| Probability and statistics, Linear Algebra, Calculus | | CT+EA | | | | | |
| Course Outcomes | • CO1: Understand the concepts Adaptive filters and systems<br>• CO2: Understand the modelling of adaptive systems and performance evaluation<br>• CO3:Understand the stability analysis of adaptive systems<br>• CO4: Understand the estimation theory for linear systems and modeling algorithms | | | | | | |
| Topics Covered | Introduction to Adaptive Filters, Adaptive filter structures, issues and examples, Applications of adaptive filters, Channel equalization, active noise control, Echo cancellation, beam forming. (6)<br>Discrete time stochastic processes: Re-visiting probability and random variables, Discrete time random processes, Power spectral density – properties, Autocorrelation and covariance structures of discrete time random processes, Eigen-analysis of autocorrelation matrices. (8)<br>Wiener filter, search methods and the LMS algorithm: Wiener FIR filter (real case), Steepest descent search and the LMS algorithm, Extension of optimal filtering to complex valued input, The Complex LMS algorithm. (8)<br>Convergence and Stability Analysis: Convergence analysis of the LMS | | | | | | |

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| | algorithm, Learning curve and mean square error behaviour, Weight error correlation matrix, Dynamics of the steady state mean square error (MSE), Mis adjustment and stability of excess MSE. (6)<br>Variants of the LMS Algorithm: The sign-LMS and the normalized LMS algorithm, Block LMS, Review of circular convolution, Overlap and save method, circular correlation, FFT based implementation of the block LMS Algorithm. (4)<br>Vector space framework for optimal filtering: Axioms of a vector space, examples, subspace, Linear independence, basis, dimension, direct sum of subspaces, Linear transformation, examples, Range space and null space, rank and nullity of a linear operator, Inner product space, orthogonally, Gram-Schmidt orthogonalization, Orthogonal projection, orthogonal decomposition of subspaces, Vector space of random variables, optimal filtering as an orthogonal projection computation problem. (10)<br>The lattice filter and estimator: Forward and backward linear prediction, signal subspace decomposition using forward and backward predictions, Order updating the prediction errors and prediction error variances, basic lattice section, Reflection coefficients, properties, updating predictor coefficients, Lattice filter as a joint process estimator, AR modelling and lattice filters, Gradient adaptive lattice. (8)<br>RLS lattice filter: Least square (LS) estimation, pseudo-inverse of a data matrix, optimality of LS estimation, Vector space framework for LS estimation, Time and order updating of an orthogonal projection operator, Order updating prediction errors and prediction error power, Time updating PARCOR coefficients. (6) |
| Text Books, and/or reference material | Text Books:<br>8. Adaptive Filters Theory.S. Heykin.Prentice Hall<br>9. Adaptive Signal Processing. B. Widrow and S. D. Stearns.Prentice Hall.<br><br>Reference books:<br>5. Fundamentals of Adaptive Signal Processing. A. Uncini. Springer.<br>6. Adaptive Signal Processing: Next Generation Solutions.T. Adaly and S. Heykin. Wiley. |

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|---|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS9055 | Semantic Web and Linked Data Engineering | PCR | 4 | 0 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| Data structure, DBMS, Web Technology, Basic Computer Logic | | CT+EA | | | | | |
| Course Outcomes | • CO1: Students can write their own semantic web page by using publicly available vocabulary.<br>• CO2: Students can publish their data in Open Data format, such that the other people can discover it easily.<br>• CO3: Students can able to develop semantic web application.<br>• CO4: Students will get exposure in this topic for further higher studies and research. | | | | | | |
| Topics Covered | Principles of Linked Data, Introduction, A Layered Approach. (4)<br>Naming Things with URIs, Making URIs Dereferenceable. (5)<br>The Semantic Web (SW) vision: What is SW? The difference between Current web and SW, SW technologies, the Layered approach. (7)<br>The XML Language, Structuring, Namespaces, Addressing and Querying XML Documents. (7)<br>Resource Description Framework, RDF syntax, RDF Schema (RDFS). (7) | | | | | | |

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| | Construction RDF and RDFS: Different syntax implementation, How to Store into server, Construction of RDFS. (6)<br>SPARQL: Query Language: Syntax and Query processing. (2)<br>Web Ontology Language OWL: OWL Syntax and Intuitive Semantics, OWL Species. (6)<br>Description Logics, Model-Theoretic Semantics of OWL. (4)<br>Ontology Engineering: Introduction, Constructing Ontologies, Reusing existing Ontologies. (4)<br>Protégé tools. ( 4) |
| Text Books, and/or reference material | Text Books:<br>1. Semantic Web Primer: second edition by Grigoris Antoniou and Frank van Harmelen<br>2. Foundations of Semantic Web Technologies byHitzler Pascal<br><br>Reference Books:<br><br>1. Ontological Engineering by Asunción Gómez-Pérez, Mariano Fernández-López, and OscarCorcho<br>2. Linked Data: Evolving the Web into a Global Data Space by Tom Heath and Christian Bizer<br>3. Harald Sack semantic web videos |

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|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9056 | Biometrics | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Basic Mathematics – Knowledge and ability to use calculus, probability, and statistics are essential. | | | | | |
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| Course Outcomes | The objectives of this course include to provide scientific foundations needed for the design, implementation, and evaluation of large-scale biometric systems. |
| Topics Covered | Biometrics Overview: Introduction, characteristics of biometric systems, biometric systems, biometric functionalities, biometrics system errors, design cycles of biometric systems, applications of biometric systems, security and privacy issues. (6)<br>Image Processing Techniques: What is image processing?, origin of image processing, fundamental steps in digital image processing, components of image processing system, image sensing and acquisition, image sampling and quantization, basic relationships between pixels. (6)<br>Filtering: Background, basic intensity transformation functions, histogram processing, fundamentals of spatial and frequency domain filtering, smoothing filters, sharpening filters, Discrete Fourier Transform, FFT. (6)<br>Pattern Classification Techniques: Introduction, Bayesian decision theory, maximum likelihood & Bayesian parameter estimation, non-parametric techniques, linear discriminant functions, multilayer NN, nonmetric methods (6)<br>Fingerprint Recognition: Introduction, ridge pattern, fingerprint acquisition, feature extraction, matching, and fingerprint synthesis. (6)<br>Face Recognition: Introduction, image acquisition, face detection, feature extraction, matching and advanced topics. (6)<br>Iris Recognition: Introduction, iris recognition systems, image acquisition, iris segmentation, iris normalization, iris encoding and matching, iris quality and performance evaluation. (6)<br>Multi-modal Biometric Systems: Introduction, sources of multiple evidence, acquisition and processing architecture, fusion levels. (4)<br>Other Biometrics: Signature, hand shape, ear, palmprint, etc. (6)<br>Identity Management Technology. (2) |

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| Text Books, and/or reference material | Text Books:<br>1. Introduction to Biometrics by Anil K. Jain, Arun Ross, and Karthik Nandakumar.<br>2. Biometric Systems: Technology, Design and Performance Evaluation by Wayman, J.L., Jain, A., Maltoni, D., Maio, D.<br>3. Guide to Biometrics by Bolle, R.M., Connell, J., Pankanti, S., Ratha, N.K., Senior, A.W.<br>4. Pattern Classification by Richard O. Duda, Peter E. Hart, David G. Stork.<br>5. Digital Image Processing by Gonzalez<br>Reference Books:<br>1. Multibiometrics Systems: Modern Perspectives to Identity Verification by D. R. Kisku, P. Gupta and M. Tistarelli<br>2. Advances in Biometrics for Secure Human Authentication and Recognition by D. R. Kisku, P. Gupta and J. K. Sing<br>3. Design and Implementation of Healthcare Biometric Systems by D. R. Kisku, P. Gupta and J. K. Sing<br>4. Developing Next-Generation Countermeasures for Homeland Security Threat Prevention, M. Dawson, D. R. Kisku, P. Gupta, J. K. Sing & W. Li |

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|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9062 | Introduction to Human Activity Recognition | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Basic Mathematics – Knowledge and ability to use calculus, probability, and statistics are essential. | | | | | |
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| Course Outcomes | The objectives of this course include to provide foundations needed for the Design, implementation, and evaluation of human activity recognition systems. |
| Topics Covered | Overview: Introduction, activity set, attributes and sensors, obtrusiveness, data collection protocol, recognition performance, energy consumption, processing. (7)<br>Methods: Feature extraction, learning, evaluation methodologies, evaluation metrics.(6)<br>Design Challenges of Human Activity Recognition Systems. (3)<br>Pattern Classification Techniques: Introduction, Bayesian decision theory, maximum likelihood and Bayesian parameter estimation, non-parametric techniques, linear discriminant functions, multilayer neural networks, nonmetric methods. (9)<br>State-of-the systems: Online systems, supervised offline systems, semi-supervised approaches. (8)<br>Incorporating physiological signals: Description, data collection, feature extraction, evaluation, and confusion matrix. (6)<br>Enabling real time systems: Existing systems, novel systems, evaluation. (5)<br>Multiple classifier systems: Types of systems, classifier level approaches, combination level approaches, probabilistic strategies, evaluation. (6)<br>Other methods: Motion templates, temporal methods, discriminative methods. (4) |
| Text Books, and/or reference material | Text Books:<br>1. Human Activity Recognition: Using Wearable Sensors and Smartphones By Miguel A. Labrador, Oscar D. Lara Yejas<br>2. Computer Vision and Action Recognition By Md. Atiqur Rahman Ahad<br>Reference Books:<br>1. Human Activity Recognition and Prediction by Yun Fu |

<table>
<tr><td colspan="9">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9063</td><td>Human Computer Interaction</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire knowledge about Components of HCI<br>• CO2: To learn the basic Psychology of Usable Things<br>• CO3: To learn aboutUsability Engineering,Usability Benchmarking<br>• CO4: To learn Inspection methods, testing methods, design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction, Psychology of Usable Things (6)<br>Usability Engineering, Know the User, Usability Benchmarking (10)<br>Goal-Oriented Interaction Design, Prototyping, (10)<br>Usability Inspection Methods, Usability Testing Methods (10)<br>Usability in Practice, Visual Design and Typography (10)<br>Icon Design, Case Studies (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, Pearson Education, 2005.<br>2. Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human ComputerInteraction, Addison-Wesley, 1994<br>Reference Book:<br>1. B. Shneiderman; Designing the User Interface, Addison Wesley 2000</td></tr>
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<tr><td colspan="9">Department of Computer Science and Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9064</td><td>Management Information Systems</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Acquire knowledge about acquiring information<br>• CO2: To learn the systems analysis<br>• CO3: To learn about systems design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction, Information systems, Decision Making Process,(6)<br>System Approach to Problem Solving, Structure of MIS (10)<br>Types of Management Systems Concepts of Management Organization (10)<br>Strategic Level Planning, Operational Level Planning (10)<br>Basics of ERP, Evolution, Enterprise Systems in Large Organizations, Benefits and Challenges (10)<br>Decision Support Systems (DSS), Artificial Intelligence (AI) (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:<br>1. Essentials of Management Information Systems, 8/E, Laudon and Laudon, 2007, Prentice Hall<br>2. Management Information Systems, Sadagopan, S., PHI</td></tr>
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| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9065 | System Analysis and Design | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| NIL | | CT+EA | | | | | |
| Course Outcomes | • CO1: Acquire knowledge about acquiring information<br>• CO2: To learn the systems analysis<br>• CO3: To learn about systems design | | | | | | |
| Topics Covered | Introduction, Requirements of information, qualities of information, SAD life cycle (6)<br>Information gathering, methods, system requirements specification (10)<br>Feasibility analysis, cost benefit analysis (10)<br>Data flow diagrams, E R Diagrams, case studies (10)<br>Object oriented systems modelling, case studies, (10)<br>Audit and security of information systems, case studies (10) | | | | | | |
| Text Books, and/or reference material | Text Books:<br>3. System Analysis and Design, Kenneth E. Kendall, Jullie E. Kendall, Pearson 2014<br>4. J. W. Satzinger, R. B. Jackson and S. D. Burd. Systems Analysis and Design in a Changing World, Thomson Course Technology, 2012. | | | | | | |

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|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9067 | Randomized Algorithms | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| IT 504 Design and Analysis of Algorithms | | CT+EA | | | | | |
| Course Outcomes | • CO1: To be able to model a problem using randomized algorithms, if it is necessary.<br>• CO2: Comparing standard randomized algorithm with its non-randomized version through analysis.<br>• CO3: Can learn tools and techniques for designing and analysing randomized algorithms. | | | | | | |
| Topics Covered | **Introduction:** Overview and Motivational Examples. (2)<br>**Tools:**<br>• Linearity of expectation; Markov inequality; Chebyshev's inequality; Chernoff bound; Union bound with examples to Randomized algorithm design. (4)<br>• Coupon Collection and Occupancy Problems. (4)<br>• Conditional Expectation and Martingales. (4)<br>• Balls, Bins and Random Graphs. (4)<br>• Markov Chains and Random Walks. (4)<br>• Probabilistic Method. (6)<br>**Applications:**<br>• Sorting; Selection; Data Structure; Graph Problems. (6)<br>• Metric Embeddings. (4)<br>• Online Algorithms. (6)<br>• Algorithms for Massive Data Set include Similarity Search. (6)<br>• Other Modern Applications. (4) | | | | | | |

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|---|---|
| Text Books, and/or reference material | **Text Books:**<br>1. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, 2nd Edition, Cambridge University press, Cambridge, MA, 1995.<br>2. Thomas H. Cormen, Charles Leiserson, Ronald Rivest, and Clifford Stein. Introduction to Algorithms. 3rd ed. MIT Press, 2009. ISBN: 9780262033848.<br>3. M. Mitzenmacher and E. Upfal, Probability and Compuitng: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press.<br>4. J. Kleinberg and E. Tardos, Algorithm Design,Pearson.<br>**Reference Book/Lecture Notes:**<br>1. D. Karger, 6.856J/18.416J: Randomized Algorithm (MIT Course), Spring 2019.<br>2. E. Demaine and S. Devadas, 6.006: Introduction to Algorithms (MIT Open Courseware), Fall 2011.<br>3. A. Goel, CME 309/CS 365: Randomized Algorithm (Staford Course), Winter 2012-13.<br>4. G. Valiant, CS265/CME309: Randomized Algorithms and Probabilistic Analysis (Stanford University Course), Fall 2018.<br>5. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, July 2008.<br>6. T. Roughgarden, CS261: A Second Course in Algorithms (Stanford University), 2016. |

| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9068 | Optimization Techniques and Decision Procedures for Computer-Aided Design and Verification | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous (CT) and end assessment (EA)) | | | | | |
| CS1001, CS1003, CS9011 | | CT+EA | | | | | |

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| Course Outcomes | • CO1: To understand the basic principles of Satisfiability Modulo Theories (SMT).<br>• CO2: To apply SMT in computer-aided verification of computer programs.<br>• CO3: To apply SAT solvers, LP Solvers and SMT Solvers in computer-aided testing and verification of VLSI Circuits.<br>• CO4: To contribute in the development of open-source SMT libraries. |
| Topics Covered | **Introduction:** Approaches to formal reasoning, Deduction and enumeration, Expressiveness, Decidability, Boolean structure in decision problems, Reduced Ordered Binary Decision Diagrams (ROBDD), Building BDDs from formulas, Propositional logic, First-order logic. (10)<br>**Decision Procedures for Propositional Logic:** Progress of SAT solving, The DPLL framework, BCP and the implication graph, Conflict clauses and resolution, Decision heuristics, the resolution graph and the unsatisfiable core, Familiarizing SAT solvers, Modelling verification problems as SAT and solving them using SAT solvers. (12)<br>**Linear Arithmetic Solvers:** Decision problems and Linear programs, Basics of the Simplex algorithm, Simplex with upper and lower bounds, Incremental problems, the branch and bound method, Fourier–Motzkin variable elimination, The Omega test, Modelling verification problems as LP and solving those using LP solvers. (10)<br>**Bit Vectors, Arrays and Pointer Logic:** Bit-vector arithmetic, deciding bit-vector arithmetic with flattening, Fixed-point arithmetic, Arrays as |

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| | uninterpreted functions, A reduction algorithm for array logic, Pointers and their applications, Analysis of programs with pointers, Pointer logic, and Adding Structure types. (10)<br>**Quantified Formulas and Combination of Theories:** Quantified Boolean Formulas (QBF), Quantifier elimination, Prenex normal form, Quantifier elimination for QBF, The Nelson–Oppen combination procedure, Lazy encodings, The SMT-LIB initiative. Familiarizing SMT solvers, solving verification problems using SMT solvers. (14) |
| Text Books, and/or reference material | **Books:**<br>1. Daniel Kroening and Ofer Strichman, "Decision Procedures, An Algorithmic Point of View", Springer-Verlag Berlin Heidelberg; 1st edition (April, 2008).<br>2. Clark Barrett, Roberto Sebastiani, Sanjit A. Seshia and Cesare Tinelli, "Chapter12: Satisfiability Modulo Theories (Handbook of Satisfiability: Volume 185 Frontiers in Artificial Intelligence and Applications)", IOS Press, (2008). |

| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS9070 | Machine Learning | PEL | 3 | 1 | 0 | 4 | 4 |

| Pre-requisites | Course Assessment methods (Continuous evaluation (CE) and end assessment (EA)) |
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| Basic Concepts of Probability and Statistics. | CE+EA |

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| Course Outcomes | • CO1: Finding problems that can't be solved by if else method;<br>• CO2: Different types of learning methods like Regression and Classification.<br>• CO3: Machine learning algorithms like ANN, SVM and Decision Tree etc.<br>• CO4: Deep Learning Methodologies like CNN, RNN and Reinforcement Learning. |
| Topics Covered | Introduction- Basic concepts. (2)<br>Supervised learning- Supervised learning setup, LMS, Linear Regression, Gradient Descent Algorithms, Batch Gradient Descent and Stochastic Gradient Descent, Logistic regression, Perceptron, Fisher Scoring, Exponential Family, Generative learning algorithms, Gaussian discriminant analysis, Naive Bayes, Support vector machines, SoftMax Regression. (20)<br>Bias/variance trade-off, Model selection and feature selection, Learning Theory, Online Learning and the Perceptron Algorithm. (10)<br>Unsupervised learning- Clustering. K-means, EM, Mixture of Gaussians, Factor analysis, PCA (Principal components analysis), ICA (Independent components analysis). (12)<br>Reinforcement learning and control - MDPs. Bellman equations, Value iteration and policy iteration, Linear quadratic regulation (LQR), LQG, Q-learning. Value function approximation. (4)<br>Deep Learning- NN architecture, Forward/Back propagation. (8) |
| Text Books, and/or reference material | Text Books:<br>4. Machine Learning - Tom M. Mitchell (TMH)<br>5. Class Notes – Prof. Andrew Ng, Stanford University<br>6. Video Lectures - Prof. Andrew Ng, Stanford University |

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|---|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS9071 | Fundamentals of Cryptography | PEL | 4 | 0 | 0 | 4 | 4 |

| Pre-requisites | Course Assessment methods (Continuous (CT) and end assessment (EA)) |
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| NIL | CT+EA |

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| Course Outcomes | • CO1: Introduce to the basic mechanisms Cryptography<br>• CO2: Notion of computationally hard problems and their applications<br>• CO3: Notion of trap-door and one-way functions and their applications<br>• CO4: The attack and cryptoanalysys |
| Topics Covered | Introduction, X.800: Security architecture for Open Systems Interconnection, Different Attack models, Adversarial Behavior. (4)<br>Classical and modern cryptographic techniques, Pseudorandom function, Family of pseudorandom functions, One-way-trapdoor function, statistical properties of random sequences, Computationally bounded & unbounded settings. (6)<br>Basic Number Theory: Properties of Prime number, Additive and multiplicative group, Quadratic residue, Primality test. (8)<br>Confidentiality: Symmetric Encryption: - DES, AES, mode of different encryptions Asymmetric Encryption: - RSA, Rabin's, El Gamaletc, Attacks and Countermeasures (10)<br>Pseudo-number generation, Stream cipher, LFSR (6)<br>Message Integrity, Message Authenticity, MAC (4)<br>Digital signature, no repudiation, RSA, ElGamal and DSA, Forgery. (8)<br>Protocol Design: SSL, PGP, TSL etc. (4)<br>Advanced topics: Shamir Secret Sharing, Deniability and Undeniable signature. (6) |
| Text Books, and/or reference material | Text Books:<br>1. Hand book of Applied Cryptography, CRC Press (free ebook)<br>2. Cryptography: Theory and Practice, Douglas Robert Stinson, Maura Paterson<br>Reference Books:<br>1. A Course in Number Theory and Cryptography, N Koblitz<br>2. Public-Key Cryptography: Theory and Practice, Abhijit Das, C. E. VeniMadhavan |

| Department of Computer Science and Engineering | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P)# | Total Hours | |
| CS 9072 | Secure Multiparty Computation | PEL | 4 | 0 | 0 | 4 | 4 |

| Pre-requisites | Course Assessment methods (Continuous evaluation (CE) and end assessment (EA)) |
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| CSE-9071 | CE+EA |

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| Course Outcomes | • CO1: Understanding secure computation in the distributed environment.<br>• CO2: Analysis of semi-honest and malicious adversary in the distributed setting.<br>• CO3: The fairness and correctness in presence of malicious parties. |
| Topics Covered | Introduction, Semi-Honest and Malicious adversary, Computationally bounded and Computationally unbounded setting, Fairness, Correctness etc. (6) |

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| | Secret Sharing, Additive Secret Sharing, Shamir's Secret Sharing, Fault tolerance secret sharing, Arithmetic on Shamir's secret, Verifiable Secret Sharing. (10)<br>Garble Circuit, Arithmetic Circuit, Arithmetic Black Box, (10)<br>Oblivious Transfer: Single bit, multiple bits, multiple bits, OT Extension. (7)<br>Zero-Knowledge Proof: Interactive and non-interactive, concurrent. (7)<br>Anonymity: Unlinkaibility, MixNet: Encryption MixNet, Decryption MixNet and Universal MixNet, Deniable MixNet. (8)<br>Some applications: Distributed Key Generation, Privacy preserving string matching, and Bitcoin architecture. (8) |
| Text Books, and/or reference material | Text Books:<br>1. Secure Multiparty Computation: Ronald Cramer, Ivan Bjerre Damgård, Jesper Buus Nielsen<br>2. Efficient Secure Two-Party Protocols: Techniques and Constructions: Carmit Hazay, Yehuda Lindell<br>3. Concurrent Zero-Knowledge: With Additional Background by Oded Goldreic: Alon Rosen |

| Department of Computer Science and Engineering | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | Title of the course | Program Core (PCR) / Electives (PEL) | Total Number of contact hours | | | | Credit |
| | | | Lecture (L) | Tutorial (T) | Practical (P) | Total Hours | |
| CS 9074 | Data Analytics | PEL | 3 | 1 | 0 | 4 | 4 |
| Pre-requisites | | Course Assessment methods (Continuous evaluation (CE) and end assessment (EA)) | | | | | |
| Basics of Linear Algebra, Calculus, Probability | | CE + EA | | | | | |
| Course Outcomes | • CO1: Knowledge in handling and analyzing extremely large datasets.<br>• CO2: Learns the techniques of uncovering hidden patterns, correlations and other insights out of these datasets.<br>• CO3: Ability to apply the concepts of data analytics in different domains.<br>• CO4: Ability to contextually integrate and correlate large amounts of information. | | | | | | |
| Topics Covered | Introduction to Data Analytics, Types of Data Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, and Prescriptive Analytics. Use Cases, Issues and Challenges in Big Data. (6)<br>Fundamentals of Statistics –Frequency Distribution. Probability: Random Variable,<br>Probability Distribution (8)<br>Similarity Measures: Cosine Similarity, Adjusted Cosine Similarity, Jaccard Similarity.<br>Missing Value Prediction Techniques: Mean Cantering, Weighted Average, Z-Score. (8)<br>Basics of Complex Network: Degree Distributions, Transitivity or Clustering. Centrality<br>Measures: Degree Centrality, Betweenness Centrality, Closeness Centrality, Eigenvector<br>Centrality, PageRank Centrality. Community Detection Techniques: Girvan-Newman,<br>Fast Greedy, Label Propagation, Clique Percolation Method. Community Quality Metrics:<br>Modularity, NMI, Conductance. (14)<br>Introduction to Data Mining – Machine Learning Techniques: Least Square Regression,<br>Decision-tree, SVM. Clustering Techniques: K-Means. (12)<br>Introduction to Hadoop Ecosystem – HDFS, Map-Reduce, PIG, HIVE, HBase, Mahout,<br>Zookeeper, Flume, Sqoop, etc. (8) | | | | | | |

<table>
<tr><td>Text Books, and/or reference material</td><td>Text Books:<br>1. Data Science and Big Data Analytics: Discovering, Analysing, Visualizing and<br>Presenting Data, EMC Education Services (Editor), Wiley, 2015.<br>2. Machine Learning: Hands-On for Developers and Technical Professionals – Jason Bell<br>Reference Books:<br>1. Networks: An Introduction – M. E. J. Newman<br>2. Hadoop: The Definitive Guide – Tom White</td></tr>
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<tr><td colspan="9">Department of Computer Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>CS 9085</td><td>Expert Systems</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">Artificial Intelligence, Pattern Recognition</td><td colspan="7">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">• CO1: Idea about Knowledge Base & Expert Systems<br>• CO2: Idea of Inference Tool and Inference Engine and different methods of Inference Methodologies.<br>• CO3: Idea about Reasoning under Uncertainty and Uncertainty Management which is really crucial under present day scenario.<br>• CO4: Concept of the Design of Expert System Components and Experts Systems<br>• CO5: Some Examples of Practical Experts System.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Introduction to Expert Systems: What is an Expert System – Advantages of Expert Systems – Characteristics of Expert Systems - Applications and Domains – Procedural and Non procedural systems. (8)<br>The Different Techniques for Knowledge Representation: Meaning of Knowledge – Productions – Semantic Nets- Frames – Logics – Propositional and Predicate Logic – The universal and existential quantifiers. (8)<br>The Different Methods of Inference : Trees, Lattice and Graph – State and Problem Space – Rules of Inference – Logic Systems – Resolution Systems and Deductions – Forward and Backward Reasoning – Meta knowledge. (9)<br>The Reasoning Under Uncertainty and Inexact Reasoning – Uncertainty – Types of Errors – Classical Probability – Experimental and Subjective probabilities – Compound and Conditional Probabilities – Temporal Reasoning – Uncertainty in Inference Chains – Evidence Combination – Uncertainty and Rules – Certainty Factors – Dempster- Shafer Theory – Approximate Reasoning. (12)<br>The Design of Expert Systems Tool and Expert Systems: Selecting Appropriate Problem – Stages in the development – Errors in Development – Expert System Life Cycle – A Life Cycle Model. (10)<br>Some Practical Examples of Expert System Design – Modular Design – Phases and Control Facts – Importing and Exporting facts – Modules and Execution Control – Certainty Factors – Decision Trees – Backward Chaining – A Monitoring Problem. (9)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:<br>1. Expert Systems Principles and Programming – Bikash Publishing House.<br>2. Pattern Classification- – Duda, Hart & Stork – J. Wiley & Sons.<br>Reference Books:<br>1. Artificial Neural Networks – B. Yegnanarayana – PHI<br>2. Neural Networks for Pattern Recognition – C.M. Bishop – Oxford</td></tr>
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