# Course Curriculum for M Tech in Computer Science and Engineering (Analytics)

Computer Science and Engineering Department

**NATIONAL INSTITUTE OF TECHNOLOGY DELHI**

(An autonomous Institute under the aegis of Ministry of Education, Govt. of India.)

# Department of Computer Science and Engineering
# National Institute of Technology Delhi

## 1.1 About the Department

The Computer Science and Engineering Department was started in 2010 along with the foundation of NIT Delhi. Initially, only the Bachelor of Technology Programme was offered with the intake 30 which presently has been increased to 120. Now, apart from B. Tech., the department also offers Master of Technology in CSE,CSE (Analytics) and Ph.D. programmes which cover a number of important areas of Computer Science and Engineering, e.g., Algorithms, Computer Networks, Data Warehousing and Data Mining, Software Engineering, Machine Learning, Image Processing, Web Technologies, Data Analytics, Complex Networks, Wireless Sensor Networks etc. We provide our students with a broad undergraduate and graduate curriculum based on the application and theoretical foundations of computer science. Our faculty and students participate in interdisciplinary research. The combination of these elements makes the department an especially exciting environment in which to study and work; an environment that serves us well in our goal of providing excellence in education, research, and discovery. The department envisions producing quality graduates, capable of leading the world in the technical realm. The department is equipped with the latest configuration and high computing system with hi-speed Internet facility, both wired as well as wi-fi. The Computer Science programs at this institute are dedicated to educate students and to advance research in computer and information technology. The department has all the facilities to carry out the related teaching and research work.

## 1.2 Vision

- To communicate quality Computer Science education for producing globally identifiable technocrats and entrepreneurs upholding sound ethics, profound knowledge, and innovative ideas to meet industrial and societal expectations.

## 1.3 Mission

- To impart value-based technical knowledge and skill relevant to Computer Science and Engineering through effective pedagogies and hands-on experience on the latest tools and technologies to maximize employability.
- To strengthen multifaceted competence in allied areas of Computer Science in order to nurture creativity and innovations to adapt the ever-changing technological scenario requiring communally cognizant solutions.
- To create an appetite for research that leads to pursuing a research career or higher education in contemporary and emerging areas of computer science.
- To inculcate the moral, ethical, and social ideals essential for prosperous nation building.

## M. Tech. Computer Science and Engineering (Analytics)

### 2.1 Preamble

**M. Tech. Computer Science and Engineering (Analytics):** The objective of the M. Tech. program in Computer Science and Engineering (Analytics) is to prepare students to undertake careers involving innovation and problem solving using computational techniques and technologies, or to undertake advanced studies for research careers. In order to give due importance to applied as well as theoretical aspects of computing, the curriculum for the M.Tech Computer Science and Engineering (Analytics) program covers most of the foundational aspects of computing sciences, and also develops in students the engineering skills for problem solving using computing sciences. The program offered at NIT Delhi is designed to equip students with a unique blend of skill sets that include:

- Life skills orientation.
- Predominantly practice-oriented approach with access to well-equipped and specialized laboratories, and supervised internship, projects, dissertation and Ph.D Thesis.
- Hands-on technical training.
- Business perspective, along with emphasis on innovation and entrepreneurship.
- Strong theoretical foundation for computer science and engineering.
- Hard and soft skills.
- Strong research environment.
- Participate in the R&D and industrial projects.

### 2.2 Salient Features

- Minimum Credits requirements for completion of MTech Computer Science and Engineering (Analytics) program is 80.
- The Curriculum is based on the guidelines of National Education Policy (NEP) – 2020.
- The curriculum is designed to meet the prevailing and ongoing industrial requirements.
- The curriculum is flexible and offers Choice Based Credit System (CBCS).
- The curriculum inherits the Value based Education and offers Interdisciplinary/ Multidisciplinary Courses.
- The Curriculum offers Digital Pedagogy & Flipped Learning with adequate motivation for Entrepreneurship/ Startups.
- The curriculum aims at the Holistic Development of the students.
- Students can attend 2 MOOC/NPTEL/any online courses (as per department list).
- Students can do any number of courses from the other IITs/NITs/or any other CFTI institutes. There will be the provision of credit transfer as per NIT Delhi norms.
- A list of online courses is proposed by the department after mapping with the existing courses and respective mentors.

### 2.3 Program Outcomes (POs)

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| **PO-1** | Ability to apply knowledge to design and analyze complex engineering problems using appropriate analytical methods. |
| **PO-2** | Ability to independently carry out research /investigation and development work to solve practical problems. |
| **PO-3** | Ability to write and present a substantial technical report/document. |
| **PO-4** | Post Graduates should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program. |
| **PO-5** | Post Graduates will show the understanding of technical communication and the impact of Engineering solutions on the society and also be aware of contemporary issues. |

### 2.4 Program Educational Objectives (PEOs)

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| **PEO-1** | Post Graduates will establish themselves as influential professionals by solving real problems through computer science knowledge and with attention to teamwork, effective communication, critical thinking, and problem-solving skills. |
| **PEO-2** | Post Graduates will demonstrate their ability to adapt to a rapidly changing environment by learning and applying new skills and technologies. |
| **PEO-3** | Post Graduates shall drive scientific and societal advancement through technological innovation and entrepreneurship. |
| **PEO-4** | Post Graduates will be prepared for excellence and leadership roles along diverse career paths, encouraging professional ethics and active participation needed for a successful career. |

### 2.5 Program Specific Outcomes (PSOs)

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| **PSO-1** | To be able to analyse, interpret and provide solutions to the advanced software tools for designing real-life computer science and engineering problems. |
| **PSO-2** | Ability to practice as an ethical Analytics Engineer or Researcher in the evolving disciplines of Computer Science and Engineering and its allied application domains by employing soft and project management skills learned through internships, project work, and collaborative projects with industry. |

### 3.1 Semester wise Credit Structure

| **Credits** | | | | | | **Total** |
|---|---|---|---|---|---|---|
| **Sl. No.** | **Courses** | **1st Year** | | **2nd Year** | | |
| | | **1st Sem** | **2nd Sem** | **3rd Sem** | **4th Sem** | 22 |
| 1 | Program Core (PC) | 11 | 11 | - | - | |
| 2 | Program Electives (PE) | 7 | 7 | - | - | 14 |
| 3 | Independent Study / Term Paper (IS-TP) | 2 | 2 | | | 4 |
| 4 | Seminar (SEM) | | | 4 | 4 | 8 |
| 5 | Thesis/Dissertation (TH-DIS) | - | - | 16 | 16 | 32 |
| **Total** | | **20** | **20** | **20** | **20** | **80** |

## Course Scheme

| Year | FIRST SEMESTER | | | | | | | SECOND SEMESTER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Course Code** | **Course Name** | **L** | **T** | **P** | **C** | | **Course Code** | **Course Name** | **L** | **T** | **P** | **C** |
| **I** | CSLM 5XX | Core 1 | 3 | 0 | 0 | 3 | | CSLM 5XX | Core 4 | 3 | 0 | 0 | 3 |
| | CSBM 5XX | Core 2 | 3 | 0 | 2 | 4 | | CSBM 5XX | Core 5 | 3 | 0 | 2 | 4 |
| | CSBM 5XX | Core 3 | 3 | 0 | 2 | 4 | | CSBM 5XX | Core 6 | 3 | 0 | 2 | 4 |
| | CSBM 6XX | Elective 1 | 3 | 0 | 2 | 4 | | CSBM 6XX | Elective 3 | 3 | 0 | 2 | 4 |
| | CSLM 6XX | Elective 2 | 3 | 0 | 0 | 3 | | CSLM 6XX | Elective 4 | 3 | 0 | 0 | 3 |
| | CSPM 504 | Independent Study -I /Term Paper- I | 0 | 0 | 4 | 2 | | CSPM 554 | Independent Study -II/ Term Paper -II | 0 | 0 | 4 | 2 |
| | | **Total Credits** | | | | **20** | | | **Total Credits** | | | | **20** |
| **Year** | **THIRD SEMESTER** | | | | | | | **FOURTH SEMESTER** | | | | | |
| | **Course Code** | **Course Name** | **L** | **T** | **P** | **C** | | **Course Code** | **Course Name** | **L** | **T** | **P** | **C** |
| II | CSPM 601 | Dissertation I | - | - | - | 16 | | CSPM 651 | Dissertation II | - | - | - | 16 |
| | CSLM XXX | MOOC Course I | 3 | 0 | 0 | 3 | | CSLM XXX | MOOC Course II | 3 | 0 | 0 | 3 |
| | CSPM 602 | Seminar I | - | - | - | 1 | | CSPM 652 | Seminar II | - | - | - | 1 |
| | | **Total Credits** | | | | **20** | | | **Total Credits** | | | | **20** |

## I. Core Courses

| S. No. | Course Code | Course Name | L | T | P | C | | S. No. | Course Code | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CSLM 501 | Computational Mathematics | 3 | 0 | 0 | 3 | | 5 | CSBM 551 | Networking and Communication | 3 | 0 | 2 | 4 |
| 2 | CSBM502 | Advanced Data Structure and Algorithms | 3 | 0 | 2 | 4 | | 6 | CSBM 552 | Advance Artificial Intelligence | 3 | 0 | 2 | 4 |
| 3 | CSBM 503 | Advanced Databases | 3 | 0 | 2 | 4 | | 7 | CSLM 554 | Statistical Methods for Research | 3 | 0 | 0 | 3 |
| 4 | CSBM 505 | Data Mining and Warehousing | 3 | 0 | 2 | 4 | | 8 | CSLM 555 | Computer Vision and Pattern Recognition | 3 | 0 | 0 | 3 |

## II. Elective Courses

| S. No. | Course Code | Course Name | L | T | P | C | | S. No. | Course Code | Course Name | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CSBM 611 | Machine Learning | 3 | 0 | 2 | 4 | | 10 | CSBM 671 | Network and Wireless Security | 3 | 0 | 2 | 4 |
| 2 | CSBM 612 | Deep Learning and Applications | 3 | 0 | 2 | 4 | | 11 | CSLM 619 | Game Theory | 3 | 1 | 0 | 4 |
| 3 | CSBM 614 | Quantum Computing | 3 | 0 | 2 | 4 | | 12 | CSLM 620 | Natural Language Processing | 3 | 0 | 0 | 3 |
| 4 | CSBM 615 | Advanced Digital Image Processing | 3 | 0 | 2 | 4 | | 13 | CSLM 621 | Reinforcement Learning & Applications | 3 | 0 | 0 | 3 |
| 5 | CSBM 616 | Motion Analytics | 3 | 0 | 2 | 4 | | 14 | CSLM 625 | Soft Computing | 3 | 0 | 0 | 3 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | CSBM 631 | Cloud Computing | 3 | 0 | 2 | 4 | | 15 | CSLM 654 | Database and Online Social Media Security | 3 | 0 | 0 | 3 |
| 7 | CSBM 632 | Internet of Things | 3 | 0 | 2 | 4 | | 16 | CSLM 673 | Wireless Sensor Networks | 3 | 0 | 0 | 3 |
| 8 | CSBM 679 | Blockchain Technology | 3 | 0 | 2 | 4 | | 17 | CSLM 676 | High Performance Computing | 3 | 0 | 0 | 3 |
| 9 | CSBM 662 | Distributed Databases | 3 | 0 | 2 | 4 | | | | | | | | |

| Course no: CSLM 501 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Computational Mathematics** |
| **Course objectives:** | This course aims to cover the concepts and fundamentals of probability, Random Variables and Probability Distributions, some Special Probability Distributions, Sampling Theory, Markov process, and various Tests of Hypotheses and Significance |
| **Course Outcomes:** | ● To introduce the concepts of probability (L1, L2).<br>● To understand the concepts of expectations and moment generating functions (L1, L3).<br>● To introduce hypothesis and its various testing (L1, L2, L4).<br>● To understand the concept of Markov process (L1, L5). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 0 | 3 | 36 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Probability, random variables, and stochastic processes |
| | Author | Papoulis, Athanasios, and S. UnnikrishnaPillai. |
| | Publisher | Tata McGraw Hill Education |
| | Edition | 2002 |
| 2. | Title | Introduction to Probability and Statistics for Engineers and Scientists |
| | Author | Sheldon M Ross |
| | Publisher | Elsevier |
| | Edition | Fifth Edition |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Introduction to Mathematical Statistics |

| | | |
|---|---|---|
| | Author | Robert V Hogg, Joseph McKean, Allen T Craig |
| | Publisher | Pearson |
| | Edition | Seventh Edition |
| **Content** | **Unit I: Introduction to Probability (7 Hours)**<br>The concept of probability, The axioms of probability, Some important theorems on Probability, Conditional Probability, Theorems on conditional probability, Independent Event's, Bayes'Theorem.<br><br>**Unit II: Random variables and probability distributions (8 Hours)**<br>Random variables, discrete probability distributions, Distribution functions for Discrete random variables, Continuous probability distribution, Distributions for Continuous random variables, joint distributions, Independent random variables. Mathematical Expectation<br>Definition, Functions of random variables, some theorems on Expectation, The variance and Standard Deviation, Moments, Moment Generating Functions, Covariance, Correlation Coefficient.<br><br>**Unit III: Sampling Theory (7 Hours)**<br>The Binomial Distribution, The Normal Distribution, The Poisson Distribution, Relations between different distributions, Central limit theorem, Uniform distribution, Chi square Distribution, Exponential distribution. Population and Sample, Sampling with and without replacement, the sample mean, Sampling distribution of means, proportions, differences and sums, the sample variance, the sample distribution of variances.<br><br>**Unit IV: Markov Chains( 7 Hours)**<br>Introduction, Computation of n step Transition Probabilities, State Classification and Limiting Distributions, Distribution of times between state changes, The M/G/1 Queuing System, Discrete parameter, Birth Death processes, Finite Markov chains with absorbing states.<br><br>**Unit V: Statistics (7 Hours)**<br>Statistical Decisions, Statistical hypotheses, Null Hypotheses, Tests of hypotheses and significance, Type I and Type II errors, level of significance, Tests involving the Normal distribution, One Tailed and Two tailed tests, Special tests of significance for large and small samples. | |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% | |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 1 | | | | | | | | | | | | 1 | |
| CO2 | 1 | 1 | 2 | | | | | | | | | | 2 | 2 |
| CO3 | 1 | 2 | 2 | 2 | 2 | 1 | | | | | | | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 1 | 2 | | | | | | | 2 | |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 502 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Advanced Data Structure and Algorithms** |
| **Course objectives:** | The purpose of this course is to apply the concepts of advanced Trees and Graphs for solving problems effectively. |
| **Course Outcomes:** | ● Analyze the complexity of algorithms and apply asymptotic notations (L3).<br>● Study of non linear data structure and applications (L2).<br>● Study of Amortized algorithms (L2).<br>● Understand and apply greedy dynamic and divide and conquer (L2)<br>● Study of randomized and approximation algorithms (L6). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 20 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Algorithm Design |
| | Author | J.Kleinberg and E. Tardos |
| | Publisher | Addison Wesley |
| | Edition | 2005 |
| 2. | Title | Introduction to Algorithms |
| | Author | T H Cormen, C E Leiserson, R L Rivest and C Stein |
| | Publisher | MIT Press |
| | Edition | 2001 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | The Design and Analysis of Computer Algorithms |
| | Author | Aho, J E Hopcroft and J. D. Ullman |
| | Publisher | Addison Wesley |
| | Edition | 1974 |

| | | |
|---|---|---|
| 2. | Title | Data Structures, Algorithms and Applications in C++ |
| | Author | S Sahni |
| | Publisher | McGraw Hill |
| | Edition | 2001 |
| 3. | Title | Algorithm Design: Foundations, Analysis and Internet Examples |
| | Author | M. T. Goodrich and R. Tamassia |
| | Publisher | John Wiley & Sons |
| | Edition | 2001 |

**Content**

**Unit I: Introduction (8 Hours)**

Introduction to Programming, Data Structure, Algorithms. Need of Algorithms Analysis, Steps in Algorithms Design, Performance of Algorithms- Asymptotic Analysis. Graphs Algorithms, Priority Queues, Skip List, Advance Tree: Heap, Splay Tree, B/B++, String and pattern matching algorithm

**Unit II: Amortized Analysis (10 Hours)**

Amortized Analysis Dynamic tables, Aggregate Method, Accounting Method, Potential Method, Disjoint set union problem. Competitive Analysis and Online Algorithms- Move-To-Front (MTF) Method, Buy vs Rent Method, Lost cow problem, Secretary Problem.

**Unit III: Probability analysis of Randomized algorithms (10 Hours)**

Linearity of Expectation, Markov model and Markov inequality, Threshold phenomena in graph analysis Linear Programming Formulation of Problem, Simplex, Duality, Ellipsoid algorithm, Interior Points. Approximation Algorithms- Type of algorithmic Problems**,** one way of coping with NP hardness, TSP, Vertex Cover

**Unit IV: Advanced Design and Analysis Techniques (8 Hours)**

Greedy Method, Divide and Conquer, recurrence relation, substitution Method, Master Theorem, Dynamic Programming, KnapSack Problem. Parallel Algorithm and External Memory Algorithm

**List of Experiments:**

1. Study and implementation of Dijkstra's Algorithm and Bellman Ford
2. Study and implementation of Kahn’s algorithm and Dinic's algorithm
3. Study and implementation of Ford–Fulkerson algorithm
4. Study and implementation of Prim's algorithm and Kruskal's algorithm
5. Study and implementation of basic operations associated with B+ Tree
6. Study and implementation of K Dimensional tree
7. Study and implementation of Rabin-Karp Algorithm

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|---|---|
| | 8. Study and implementation of KMP Algorithm and Union by rank algorithm<br>9. Study and implementation of Path compression<br>10. Study of Research paper |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 2 | 2 | 2 | 2 | 2 | | | | | | | 2 | 2 | 3 |
| CO2 | 2 | 3 | 2 | 3 | 2 | | | | | | | 1 | 2 | 2 |
| CO3 | 2 | 3 | 2 | 2 | 2 | | | | | | | 2 | 3 | 3 |
| CO4 | 3 | 2 | 2 | 2 | 2 | | | | | | | 1 | 3 | 2 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 503 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Advanced Databases** |
| **Course objectives:** | The purpose of this course is to understand and explore the different types of data, the concepts of row-oriented and column-oriented databases, apply R for data analytics and explore various applications of evolving databases. |
| **Course Outcomes:** | ● Understand Big Data types and models, identify storage complexities, and apply concepts to real-world scenarios like Online Social Media and E-commerce Sites (L1, L2).<br>● Identify the difference between OLTP and OLAP, apply E.F. Codd's OLAP guidelines, and evaluate row vs. column-oriented databases for optimal data processing (L3, L4).<br>● Understand and apply R for data analytics, integrate with databases and business intelligence systems, and derive insights from datasets for informed decision-making (L2, L4).<br>● Implement and study semi-structured databases (L1, L3, L5) |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 38 + 20 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

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|---|---|---|
| 1. | Title | Database System Concepts |
| | Author | Henry F Korth, Abraham Silberschatz, S. Sudurshan |
| | Publisher | McGraw-Hill |
| | Edition | Sixth Edition, 2011 |
| 2. | Title | Fundamentals of Database Systems |
| | Author | Ramez Elmasri , Shamkant B. Navathe |

| | | |
|---|---|---|
| | Publisher | Pearson Education |
| | Edition | Seventh Edition, 2015 |
| **Reference Book:** | | |
| 1. | Title | Database Systems-A Practical Approach to design,Implementation and Management |
| | Author | Thomas Connolly, Carolyn Begg |
| | Publisher | Addison Wesley |
| | Edition | Sixth Edition, 2015 |
| 2. | Title | Oracle Big Data Handbook |
| | Author | Tom Plunkett, Brian Macdonald, Bruce Nelson, Mark Hornick, Helen Sun, Khader Mohiuddin, Debra Harding, Gokula Mishra, Robert Stackowiak, Keith Laker and David Segleau |
| | Publisher | McGraw Hill |
| | Edition | First Edition, 2013 |
| 3. | Title | Data Analytics using R |
| | Author | Seema Acharya |
| | Publisher | McGraw-Hill |
| | Edition | First Edition, 2013 |

**Content**

**Unit I: Big Data and Types and Applications (10 Hours)**

Unstructured, Semi-Structured and Structured Data. Managing Big Data: Schema based Model and Schema Less Model Data Storage and Retrieval Concerns: Motivation, characteristics and complexities. Case Study: Online Social Media and Ecommerce Sites.

**Unit II: OLAP and OLTP (08 Hours)**

Online Transaction Processing (OLTP) Versus Online Analytical Processing (OLAP), E.F. Codd's Guidelines for OLAP, Row Oriented Databases, Column Oriented Databases.

**Unit III: Data Analytics (08 Hours)**

Data Analytics Using R with Databases and Business Intelligence Systems.

**Unit IV: XML Databases (08 Hours)**

XML, XPath and XQuery, XSLT, Integrating XML with Databases.

**Unit V: Evolving Databases (06 Hours)**

Migration from relational to other databases based on various applications

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| | **List of Experiments:**<br>1. Advanced concepts of row-oriented databases and performing operations like schema creation, indexing, and views.<br>2. Install a column-oriented database and make a step-by-step installation guide.<br>3. Perform various operations like schema creation, indexing, and views for column oriented databases.<br>4. Query Execution Time Based Comparison Between Row-Oriented Database and Column-Oriented Database.<br>5. Explore Physical level storage structure of Postgres DB.<br>6. Explore R and perform various tasks like Installation, Connection, Basic Create, and Insert.<br>7. Perform operations like import and export using R into a row-oriented database.<br>8. Create the XSD from the XML documents and validate them.<br>9. Write queries in XQuery on different scenarios like Bibliography, Bank, and Company.<br>10. Write XML queries based on different use-case scenarios. |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 1 | 3 | 1 | | 2 | 1 | | | | | 3 | 2 | 2 |
| CO2 | 3 | 2 | 2 | | 1 | 1 | | | | 1 | 1 | 2 | 2 | 3 |
| CO3 | 2 | 3 | 3 | 1 | | **2** | **2** | **1** | | 2 | | 2 | 1 | 2 |
| CO4 | 3 | 2 | 3 | | 2 | **2** | | | | | | 2 | 2 | 2 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 505 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Data Mining and Warehousing** |
| **Course objectives:** | The purpose of this course is to know the fundamental concepts of Data Mining and Warehousing, explore tools and practices for working with Data and apply analytics on structured and unstructured data. |
| **Course Outcomes:** | ● Explain the concept and significance of Data Mining (L2).<br>● Explore Recent Trends in Data Mining such as Web Mining, Spatial-Temporal Mining (L2).<br>● Analyze different mining algorithms and clustering techniques for Data Analytics (L3).<br>● Design and Develop a Data Warehouse for an organization (L6). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 22 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Data Mining Concepts and Techniques |
| | Author | Jiawei Han and Micheline Kamber |
| | Publisher | Morgan Kaufmann |
| | Edition | 2011 |
| 2. | Title | Data Mining: Practical Machine Learning Tools and Techniques |
| | Author | Eibe Frank and Ian H. Witten |
| | Publisher | Morgan Kaufmann |
| | Edition | Third Edition, 2011 |
| 3. | Title | Introduction to Data Mining |
| | Author | Pang-Ning Tan Michael Steinbach Vipin Kumar |
| | Publisher | Pearson |

| | | |
|---|---|---|
| | Edition | Second Edition, 2016 |
| **Reference Book:** | | |
| 1. | Title | Database Concepts |
| | Author | Abraham Sibertschatz, Henry F. Korth and S. Sudarshan |
| | Publisher | McGraw Hill |
| | Edition | Seventh Edition, 2019 |
| **Content** | | |

**Unit I: Introduction to Data Mining and Data Warehouse (8 Hours)**

Design Guidelines for Data Warehouse Implementation, Multidimensional Models, OLAP – Introduction, Characteristics, Architecture, Multidimensional view, Efficient Processing of OLAP Queries, OLAP Server Architecture, ROLAP versus MOLAP Versus HOLAP and Data Cube, Data Cube Operations, Data Cube Computation. Motivation for data mining, Introduction to data mining system, Data mining functionalities, KDD, Data object and attribute types, Statistical description of data, Issues and Applications

**Unit II: Machine Learning Concepts and Approaches (6 Hours)**

Supervised Learning Framework, Concepts & Hypothesis, Training & Learning, Boolean Functions and Formulae, Monomials, Disjunctive Normal Form & Conjunctive Normal Form, A Learning Algorithm for Monomials.

**Unit III: Data Preparation and Minning Association Rules (8 Hours)**

Data cleaning, Data integration and transformation, Data reduction, Data discretization and Concept Hierarchy Generation, Data mining primitives. Frequent patterns, Market basket analysis, Frequent itemsets, closed itemsets, association rules, Types of association rule (Single dimensional, multidimensional, multilevel, quantitative), Finding frequent itemset (Apriori algorithm, FP growth), Generating association rules from frequent itemset, Limitation and improving Apriori, From Association Mining to Correlation Analysis, Lift.

**Unit IV: Classification and Prediction and Cluster Analysis (8 Hours)**

Issues regarding Classification & Prediction, Classification by Decision Tree Induction, Bayesian Classification, Classification by Back Propagation, k-Nearest Neighbour Classifiers, Genetic Algorithms, Rough Set & Fuzzy Set Approaches.

| | |
|---|---|
| | **Unit V: Cluster Analysis (6 Hours)**<br><br>Types of Data in Clustering Analysis, Categorization of Major Clustering Methods, Hierarchical Methods, Density-based methods, Grid-based methods, Grid-based methods, Model-based Clustering Method.<br><br>**List of Experiments:**<br>1. Load Data from heterogenous sources including text files into a predefined warehouse schema.<br>2. Design a data mart for a bank to store the credit history of customers in a bank. Use this credit profiling to process future loan applications.<br>3. Feature Selection and Variable Filtering (For very large data sets).<br>4. Association Mining in large data sets.<br>5. Interactive Drill-Down, Roll up, Slice and Dice Operations.<br>6. Generalized EM and k-Means Cluster Analysis.<br>7. Generalized Additive Models (GAM).<br>8. General Classification Regression Tress (GTrees)<br>9. General CHAID (Chi-square Automatic Interaction Detection) Models.<br>10. Interactive Classification and Regression Trees.<br>11. Goodness of Fit Computations. |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 1 | 2 | 1 | | 2 | 1 | | | | | 2 | 2 | 2 |
| CO2 | 3 | 2 | 2 | | 1 | 1 | | | | | 2 | 3 | 2 | 2 |
| CO3 | 2 | 3 | 2 | 2 | | 2 | 3 | | | 2 | | 2 | 1 | 2 |
| CO4 | 3 | 2 | 3 | | 2 | 3 | | | | | | 3 | 2 | 2 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 551 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |
| **Type of course** | **Program Core** | | | | |
| **Course Title** | **Networking and Communication** | | | | |
| **Course objectives:** | The purpose of this course is to Build an understanding of the fundamental concepts of computer networking, protocols, architectures, and applications, and gain expertise in design, implement and analyze performance perspective of ISO-OSI layered Architecture. It enables to understand the major issues of the layers of the model and implement new ideas in Networking through semester long projects. . | | | | |
| **Course Outcomes:** | ● Explain the concept of layering and various data communication techniques (L2).<br>● Explore various MAC protocols and understand related-issues in Computer Networks (L2).<br>● Analyze TCP/IP variants, network Algorithms, Protocols and their functionalities (L4).<br>● Explore and Analyze Recent Trends in Network Security (L4). | | | | |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 20 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Computer Networks: A Systems Approach |
| | Author | Larry Peterson and Bruce Davie |
| | Publisher | The Morgan Kaufmann Series, Elsevier |
| | Edition | 5th Edition |
| 2. | Title | Computer Networking: A Top-Down Approach Featuring the Internet |
| | Author | J.F.Kurose and K.W.Ross |
| | Publisher | Pearson Education |

| | | |
|---|---|---|
| | Edition | 6th Edition |
| **Reference Book:** | | |
| 1. | Title | TCP/IP Protocol Suite |
| | Author | Behrouz A. Forouzan |
| | Publisher | McGraw-Hill Education |
| | Edition | 4th Edition, 2009 |
| 2. | Title | Data and Computer Communications |
| | Author | William Stallings |
| | Publisher | Pearson Education |
| | Edition | 10th Ed,2013 |
| **Content** | | |

**Unit I: Networking Principles and layered architecture (4 Hours)**

Data Communications and Networking: A Communications Model Data Communications - Evolution of network, Requirements , Applications, Network Topology (Line configuration, Data Flow), Protocols and Standards, Network Models (OSI, TCP/IP).

**Unit II: Circuit and Packet switching (8 Hours)**

Switched Communications Networks Circuit Switching Packet Switching Comparison of Circuit Switching and Packet Switching Implementing Network Software, Networking Parameters(Transmission Impairment, Data Rate and Performance).

**Unit III: Data Link Layer (10 Hours)**

Error Detection and Correction Hamming Code , CRC, Checksum- Flow control mechanism Sliding Window Protocol - GoBack - N - Selective Repeat - Multiple access Aloha - Slotted Aloha - CSMA, CSMA/CD Multiple Access Networks (IEEE 802.3), Token Ring(IEEE 802.5) and Wireless Networks (IEEE 802.11, 802.15).

**Unit IV: Networking Layer & Routing Protocols (8 Hours)**

PV4 Address Space Notations Classful Addressing Classless Addressing Network Address Translation IPv6 Address Structure IPv4 and IPv6 header format. Routing - Link State and Distance Vector Routing Protocols- Implementation - Performance Analysis - Packet Tracer.

**Unit V: Recent Trends in Network Security (6 Hours)**

Network Security - Cryptography, Network layer security (IPSec), Transport Layer Security (TLS/SSL, HTTPS), QoS Parameters.

**List of Experiments:**

1. Configuration and logging to a CISCO Router and introduction to the basic user Interfaces.

| | |
|---|---|
| | 2. Configuration of IP addressing for a given scenario for a given set of topologies<br>3. Capture ICMPv4 packets generated by utility programs and tabulate all the captured parameters using Wireshark.<br>4. Configure IPv6 network using any network simulator.<br>5. Configure IP routing with RIP and OSPF.<br>6. Configure User Datagram Protocol(UDP).<br>7. Configure Transmission Control Protocol(TCP).<br>8. Configure Dynamic Host Configuration Protocol(DHCP), Domain Name Server (DNS), File Transfer Protocol (FTP) and Hypertext Transfer Protocol (HTTP).<br>9. Use Telnet to Login a remote machine • Connect remote machine using Secure Shell (SSH).<br>10. Configure SMTP, POP3 and IMAP |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | **1** | | | | | | | | | | | | **1** | |
| CO2 | **2** | **1** | | | | | | | | | | | **2** | **2** |
| CO3 | **2** | **1** | **2** | **1** | **2** | **2** | | | | | | | **3** | **3** |
| CO4 | **2** | **2** | **2** | **2** | **1** | **2** | | | | | | | **2** | |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 552 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Advanced Artificial Intelligence** |
| **Course objectives:** | The purpose of this course is to gain a comprehensive understanding of Artificial Intelligence, covering its historical development, problem-solving techniques, search strategies, logical reasoning, and planning methods, with a focus on practical applications, particularly in the field of robotics, and develop essential skills to tackle complex AI challenges effectively. |
| **Course Outcomes:** | ● Understand the basic concepts of AI (L1, L2).<br>● Apply search strategies to solve AI problems (L3).<br>● Apply knowledge representation and reasoning to solve real world AI Problems (L3).<br>● Explore machine learning concepts and algorithms for real world applications (L4). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 20 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Artificial Intelligence : A Modern Approach |
| | Author | Stuart Russell, Peter Norvig |
| | Publisher | Prentice Hall |
| | Edition | Fourth edition, 2020 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Artificial Intelligence: A New Synthesis |
| | Author | Nils J. Nilsson |
| | Publisher | Morgan-Kaufmann |
| | Edition | 1998 |

| | | |
|---|---|---|
| 2. | Title | Heuristics: Intelligent Search Strategies for Computer Problem Solving |
| | Author | Judea Pearl |
| | Publisher | Addison-Wesley Publishing Company |
| | Edition | 1984 |

**Content**

### Unit I: Introduction and Automated Problem Solving Agent (06 Hours)

What is Artificial Intelligence, History of AI, Possible Approaches in AI, Application
Domains and Modern AI, Areas Contributing to AI, Core Capabilities covered in this course, Automated Problem Solving Agent: Intelligent Agent & Environment, Complex Problems and AI, Shannon number, Problem Representation in AI.

### Unit II: Search Strategies and Logic Detection (10 Hours)

Search Strategies: Search introduction, Uninformed Search, Informed/Heuristic Search, Beyond Classical Search, Local Search, Problem Reduction, Adversarial Search, Constraint Satisfaction Problems. Logic and Deduction: Logical Agents, Propositional logic and Predicate Logic, Forward & Backward Chaining, Inferencing By Resolution Refutation.

### Unit III: AI Planning (6 Hours)

AI Planning: AI Planning, Robot introduction and types, Steps in Robot Motion Planning, Graph-based Planning (Grassfire , Dijkstra & A* Algorithm), Graph Construction Methods and path planning in Configuration Space, Skeletonization [Visibility Graphs, Voronoi diagrams/Trapezoidal Decomposition, Cell decomposition [X-connected grids – lattice-based graphs], Collision Detection and Freespace Sampling, Intruder Finding Problem, Probabilistic roadmaps(PRM)], Rapidly Exploring Random Trees (RRT).

### Unit IV: Reasoning Under Uncertainty (6 Hours)

Quantifying Uncertainty, Basic of Probability, Probabilistic Reasoning, Bayes Net, Bayesian Network, Fuzzy Logic, Decisions Theory, Utility Function, Decision Network, Markov Decision Process, Probabilistic Reasoning over time, Hidden Markov Model, Kalman filter, Markov Chain Monte Carlo.

### Unit V: Learning from examples (8 Hours)

Reinforcement Learning, Learning Agent, Introduction to Machine Learning, Types of Machine Learning, Learning from experience: Reinforcement Learning, Background, Model based and Model free learning, TD and Q Learning, RL Applications, Learning from Example, Supervised learning : Introduction, Naive Bayes, Decision Tree, Perceptrons, Neural Network, Introduction to Deep Learning. AI Applications and Ethics, Computer Vision and Robotics, natural language understanding, AI in Healthcare, Ethics of AI.

### List of Experiments:

1. Introduction to Prolog programming

| | |
|---|---|
| | 2. Python Frameworks Tutorial (with Jupyter and Colab) and it's Data Structures<br>3. Searching in graph based problem space, exploring Uninformed search Techniques<br>4. Exploring Informed search Techniques (Vacuum world and Maze Problem)<br>5. Exploring Uninformed and Informed search Techniques ( PACMAN Search Space)<br>6. Multi agent in a search space<br>7. Introduction Logical Agent and Knowledge representation using Prolog<br>8. Reasoning Under Uncertainty using Bayesian Learning<br>9. Reinforcement Learning using Q-Learning<br>10. Introduction to Machine Learning and Python libraries for Data Analysis (Pandas, NumPy, Matplotlib) |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | | | | | | | | | | | | 2 | 2 |
| CO2 | 2 | 3 | 3 | 3 | 3 | | | | | | | | 3 | 3 |
| CO3 | 2 | 2 | **3** | **3** | **3** | | | | | | | | 3 | 3 |
| CO4 | 2 | 2 | **3** | **3** | **3** | | | | | | | | 3 | 3 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSLM 554 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Statistical Methods for Research** |
| **Course objectives:** | This course aims to cover the fundamentals of statistics, and explain the different statistical approaches to test and analyze scenarios. It also aims to introduce the principles of research report writing. |
| **Course Outcomes:** | ● Define and explain the different statistical distributions (L2).<br>● Apply the basic rules and theorems in probability (L3).<br>● Use standard software to facilitate statistical analysis (L3).<br>● Design and Develop research reports (L6). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 0 | 3 | 36 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Statistical Methods for Research Workers |
| | Author | Sukhwinder Singh, M. L. Bansal, T. P. Singh and R K Jindal |
| | Publisher | Kalyani Publishers |
| | Edition | 2014 |
| 2. | Title | Probability, Statistics, & Reliability for Engineers |
| | Author | Ayub Bilal, and Richard H. McCuen |
| | Publisher | CRC Press |
| | Edition | Third Edition, 2011 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Introduction to Statistical methods |
| | Author | Jai P. Gupta and S. S. Saini |
| | Publisher | Kalyani Publishers |
| | Edition | 1980 |
| 2. | Title | Probability and Statistics for Engineering and the Sciences |
| | Author | Jay L. Devore |

| | | |
|---|---|---|
| | Publisher | Cengage |
| | Edition | Eighth Edition, 2012 |
| 3. | Title | Statistical Methods |
| | Author | S P Gupta |
| | Publisher | Sultan Chand & Sons |
| | Edition | 2012 |

**Content**

### Unit I: Introduction to Statistics (6 Hours)

Populations and Samples, Frequency tables and graphs, Grouped data and Histograms, Stem and Leaf plots, Box plots, Sample Mean, Sample Median, Sample Mode, Sample. Variance and Sample Standard Deviation, Range, Quartiles, Inter-quartile rangeRole of Statistics in Engineering

### Unit II: Introduction to Probability (8 Hours)

Basic concepts; random variables; probability functions, laws of probability, Mean and standard deviation of discrete and continuous random variables; Percentile of a random variable; Binomial Distribution, Normal distributions; normal probability plot; Poisson Distribution

### Unit III: Probability and fitting of standard frequency distribution (8 Hours)

Sampling techniques, Sampling distributions Correlation and Regression: Simple correlation and regression analysis, Partial, Multiple and Intraclass correlation, Multiple Regression analysis.

### Unit IV: Large sample tests and confidence intervals (8 Hours)

Analysis of Variance for one-way and two way classification, Transformation of Data.

### Unit V: Interpretation and Report Writing (6 Hours)

Interpretation, its need, techniques, precautions, Analysis vs Interpretation, Report Writing - objectives, characteristics, significance, steps in report writing, format, references, and ethics in research.

**Course Assessment**

**THEORY Evaluation**:

- Continuous Evaluation: 25%
- Mid Semester: 25%
- End Semester: 50%

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | | | | | | | | | | 2 | 2 |
| CO2 | 2 | 2 | 2 | | 2 | | | | | | | | 2 | 2 |
| CO3 | 3 | 2 | 2 | | 2 | 2 | | | | | | | 2 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | 2 | 2 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSLM 555 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | YES | NO | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Core** |
| **Course Title** | **Computer Vision and Pattern Recognition** |
| **Course objectives:** | The course focuses on applications of pattern recognition techniques to problems of machine vision. This course is a broad introduction to computer vision. Topics include camera models, multi-view geometry, reconstruction, some low-level image processing, and high-level vision tasks like image classification and object detection. |
| **Course Outcomes:** | ● Apply mathematical modeling methods for low, intermediate, and high-level image processing tasks (L3).<br>● Design a new algorithm to solve a recent of the art computer vision problem.<br>● Perform software experiments on the computer vision problems and compare their performance with the state of the art (L4).<br>● Build a complete system to solve a computer vision problem (L6). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 0 | 3 | 36 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Computer Vision: Algorithms and Applications |
| | Author | Richard Szeliski |
| | Publisher | Springer |
| | Edition | Second Edition |
| 2. | Title | Pattern classification |
| | Author | Duda, Richard O., Peter E. Hart, and David G. Stork |
| | Publisher | Wiley |
| | Edition | Second Edition |

<table>
<tr><td colspan="3">Reference Book:</td></tr>
<tr><td rowspan="4">1.</td><td>Title</td><td>Computer Vision: a Modern Approach</td></tr>
<tr><td>Author</td><td>David Forsyth and Jean Ponce</td></tr>
<tr><td>Publisher</td><td>Pearson</td></tr>
<tr><td>Edition</td><td>Second Edition</td></tr>
<tr><td>Content</td><td colspan="2">Unit I: Introduction to computer vision (4 Hours)<br>Human vision, Image formation: Geometric primitives and transformations , Photometric image formation , The digital camera, How machine sees and recognizes things , Applications , Mathematical foundations<br><br>Unit II: Pattern Recognition (8 Hours)<br>Basics of pattern recognition, Design principles of pattern recognition system, Learning and adaptation, Pattern recognition approaches. Statistical Pattern Recognition : Bayesian Decision Theory, Classifiers, Normal density and discriminant functions, Dimension reduction methods – Principal Component Analysis (PCA), Fisher Linear discriminant analysis, Expectation maximization (EM)<br><br>Unit III: Convention computer vision and pattern recognition algorithms (10 Hours)<br>Object detection and segmentation e.g. Edge, texture, region, detection of sliding windows : Feature extraction, e.g. linear binary pattern, principal component analysis, Gabor filters, bags of features , Matching and recognition e.g. Bayesian classifier, support vector machine, fusion , Image alignment and stitching,<br><br>Unit IV: Motion estimation, Computational photography (6 Hours)<br>Photometric calibration , High dynamic range imaging, Super-resolution, denoising, and blur removal, Image matting and compositing, Texture analysis and synthesis<br><br>Unit V: Deep learning for computer vision and pattern recognition (8 Hours)<br>Key components and basic architecture of deep neural network , Convolution neural network, Object detection using R-CNN, Segmentation using image-to-image neural network, Temporal processing and recurrent neural network.</td></tr>
<tr><td>Course Assessment</td><td colspan="2">THEORY Evaluation:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50%</td></tr>
</table>

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 1 | | | | | | | | | | | | 1 | |
| CO2 | 1 | 1 | 2 | | | | | | | | | | 2 | 2 |
| CO3 | 1 | 2 | 2 | 2 | 2 | 1 | | | | | | | 2 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 1 | 2 | | | | | | | 2 | |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 611 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES /NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | NO | YES | NO | NO | NO |
| **Type of course** | **Program Elective** | | | | |
| **Course Title** | **Machine Learning** | | | | |
| **Course Coordinator** | | | | | |

| | |
|---|---|
| **Course objectives:** | To provide an introduction to the fundamentals of machine learning and provide related mathematical background necessary for machine learning. |
| **Course Outcomes:** | ● Define the basic concepts of machine learning (L1).<br>● Awareness about off-the shelf machine learning algorithms such as logistic regression, Random Forest, and Neural Networks (L2, L3).<br>● Explain overfitting, underfitting as well as real-world applications of classical machine learning techniques (L3).<br>● Understanding of ensemble techniques (L3).<br>. |
| **POs** | |

| | Autumn: Yes | | Spring: | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 18 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Understanding Machine Learning: From Theory to Algorithms |
| | Author | Shalev-Shwartz, Shai, and Shai Ben-David |
| | Publisher | Cambridge University Press |
| | Edition | 2014 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Pattern recognition and machine learning |
| | Author | Christopher M. Bishop |
| | Publisher | Springer |

| | | |
|---|---|---|
| | Edition | 2006 |
| 2. | Title | Tom Mitchell |
| | Author | Machine Learning |
| | Publisher | Tata Mc Graw Hill |
| | Edition | 1997 |

| | | |
|---|---|---|
| 3. | Title | Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong |
| | Author | Mathematics for machine learning |
| | Publisher | Cambridge University Press |
| | Edition | 2020 |

**Content**

**Unit I: Basic Mathematics and Introduction for Machine Learning (08 Hours)**

Linear and convex optimization, eigen values, eigen vectors and vector spaces, introduction to machine learning, and empirical risk minimization.

**Unit II: Regression and Bayes Classification (06 Hours)**

Linear regression, logistic regression, gradient descent, and Bayes classifier.

**Unit III: Classification (10 Hours)**

Support vector machine, Decision Trees, Random Forest, and Principal Component Analysis.

**Unit IV: Neural Networks (08 Hours)**

Distributed Transaction Processing, Distributed Concurrency Control, Distributed DBMS Reliability.

**Unit V: NoSQL Databases and its Types (08 Hours)**

Different types of NoSQL Databases:Key-value Stores, Wide –column Stores, Document Stores, Graph Stores.

**List of Experiments:**

1. Create two databases on single DBMS and design database to horizontal fragment and share the fragments from both databases.
2. Create two databases on single DBMS and design database to vertical fragment.
3. Create two databases on single DBMS and design database to hybrid fragment and share the fragments from both database and write single query for creating view.
4. Working with Database Link in Oracle: create a Database Link with UserName and Password and create a Database

| | |
|---|---|
| | Link without UserName and Password.<br>5. Write the code to create a private database link that points to the remote database named Employee and retrieve information from Employee.<br>6. Write the code to create a public database link, pub_emp_link that points to the remote database named Employee and retrieve information from Employee.<br>7. Write the code to create a global database link using Oracle Net Manager.<br>8. Write a Program to implement of Lamport's Logical Clock<br>9. Case study on NoSQL |

| | |
|---|---|
| **Course Assessment** | **THEORY Evaluation**:<br>● Continuous Evaluation: 25%<br>● Mid Semester: 25%<br>● End Semester: 50% |
| | **LAB Evaluation**:<br>● Continuous Evaluation: 50%<br>● End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |
| | |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | | 1 | 1 | | 3 | 1 | | | | | 3 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 1 | | | | 1 | 1 | 2 | 3 | 2 |
| CO3 | 1 | | **2** | **1** | **3** | **2** | **2** | **2** | **1** | 2 | | 3 | 3 | 2 |
| CO4 | 2 | 2 | **2** | **3** | **1** | **2** | | | | | 2 | 2 | 3 | 1 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 612 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) |
|---|---|---|---|---|
| | NO | YES | NO | NO |
| **Type of course** | **Program Elective** | | | |
| **Course Title** | **DEEP LEARNING AND APPLICATIONS** | | | |
| **Course Coordinator** | | | | |
| **Course objectives:** | The purpose of this course is to provide the students with the advance knowledge of Machine learning. It aims to enable the students to understand the design of various Deep Learning models and application | | | |
| **COs** | **CO1:** Solve problems in linear algebra, probability, optimization, and machine learning. | L1, L2, L3 | | |
| | **CO2:** Implement deep learning models in Python using the PyTorch library and train them with real-world datasets. | L4, L5, L6 | | |
| | **CO3:** Design convolutional networks for handwriting and object classification from images or video. | L4, L5, L6 | | |
| | **CO4:** Design recurrent neural networks with attention mechanisms for natural language classification, generation, and translation. | L4, L5, L6 | | |

| **Semester** | **Autumn: YES** | | **Spring: YES** | | |
|---|---|---|---|---|---|
| **III** | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 22 |
| **Prerequisite course code as per proposed course numbers** | CSLM 501 | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Deep Learning |
| | Author | Ian Goodfellow and Yoshua Bengio and Aaron Courville. |
| | Publisher | MIT Press |
| | Edition | 2016 |

Reference Book:

| | | |
|---|---|---|
| 1. | Title | Machine Learning: An Algorithmic Perspective, Second Edition |
| | Author | Stephen Marsland |
| | Publisher | Chapman and Hall/CRC |
| | Edition | 2nd |
| 2. | Title | Introduction to Probability For Data Science |
| | Author | Stanley H. Chan |

| | | |
|---|---|---|
| | Publisher | Michigan Publishing |
| | Edition | May 2021 |
| **Content** | **Unit** – 1<br>**Introduction:**<br>Well posed learning problem, Types of Machine Learning, Applications, Linear Algebra, Probability and Information Theory, Numerical Computation<br><br>**Unit** – 2<br>**Traditional Machine Learning Basics:** Linear Regression, Logistic, Regression, k-Nearest Neighbors, Classifier with Probability Theory, Decision Trees, Random Forest, Support Vector Machine,<br>**Artificial Neural Network:** Artificial Neuron, Perceptron, Stochastic Gradient Descent, and Back Propagation Neural Network, Neural Network Architecture, NN with One Hidden Layer, NN with One Hidden Layer and Multiple Outputs, Neural Network Hyper-parameters<br><br>**Unit** – 3<br>**Deep Architecture:** need, applications, Hyper-parameters in Deep Neural Networks ( Encoding, Layers, Loss function, Learning Rate, Momentum and Optimization, Regularization and dropout, Batch Norms) , vanishing gradient problem, and ways to mitigate it<br><br>**Convolution Neural Network:** from Dense Layers to Convolutions, pooling layers, CNN Architectures ( AlexNet, VGG, NiN, GoogLeNet, ResNet, DensNet), Application in Image segmentation, Automated Object Detection models.<br><br>**Unit** – 4<br>**Deep Sequence Models:** Sequence Modeling Problems, Motivation and Applications, Traditional Models: Recurrent Neural Networks, Back-propagation through time; Modern Recurrent Neural Networks: Gated Recurrent Units, Long Short Term Memory (LSTM), Deep Recurrent Neural Networks, automatic image captioning, video to text with LSTM models.<br><br>Unit- 5<br>**Deep Unsupervised Learning:** Latent variable models, Autoencoders, Deep Generative Modeling: Variational Autoencoders, Generative Adversarial Networks (GANs), Recent Advance, Image generation with Generative adversarial networks,<br><br>**Advance Topic in Deep Learning:**<br>Transfer Learning: Need and motivation, Transfer Learning Process, Data Augmentation, Applications<br><br>**Unit** –6<br>**Deep Reinforcement Learning:** Components of an RL - (Agent, Policy, Value function, Model), MDP, DP, TDL, Q-Learning. SARSA Learning, Deep-Reinforcement Learning Need and Applications, Types of Deep-RL : Deep Q-Network (DQN) , Policy Gradient [ Advantage Actor-Critic (A2C/A3C), DDPG, PPO] , Alpha zero<br>Future Trends in Deep Leaning, Attention models for computer vision tasks. | |
| **Course Assessment** | Continuous Evaluation 25% | |
| | Mid Semester 25% | |
| | End Semester 50% | |

**List of Lab Experiments:**

1. Python Frameworks Tutorial (with Jupyter and Colab) and it's Data Structures
2. Introduction to Python libraries for Data Analysis (Pandas, NumPy, Matplotlib)
3. Data Collection & Creation Using Web Scraping- Static and Dynamic Webpages
4. Exploratory Data Analytics and Feature Engineering
5. Regression Techniques: Linear and Logistic
6. Traditional Computational Techniques
7. Implementation of Perceptron for logic gates (AND, OR, NOT)
8. Neural networks for Binary Classification
9. Building CNN Image classifier using keras for image classification
10. Introduction to Sequence Models for Prediction
11. Financial Planning via Deep Reinforcement Learning

Course Matrix (CO-PO-PSO Mapping)

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| **CO1** | 3 | 3 | 3 | 3 | 3 | | | | | | | | 3 | 3 |
| **CO2** | 2 | 2 | 3 | 3 | 3 | | | | | | | | 3 | 3 |
| **CO3** | 2 | 2 | 3 | 3 | 3 | | | | | | | | 3 | 3 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | | | | | | | | 3 | 3 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 614 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) |
|---|---|---|---|---|
| | NO | YES | NO | NO |
| **Type of course** | **Program Elective** | | | |
| **Course Title** | **Quantum Computing** | | | |
| **Course Coordinator** | | | | |
| **Course objectives:** | The purpose of this course is to provide the students with state-of-the-art knowledge in the field of quantum computing Various aspects of the topics will be discussed, including concepts of physics and mechanics | | | |
| **COs** | CO1. Understand the basics of quantum computing(K2<br>CO2. Apply Physics & Mechanics in quantum computing.(K3)<br>CO3. Analysis of Quantum Circuits & Information.(K4)<br>CO4. crate and evaluate the Quantum Algorithm.(K5,K6) | | | |

| **Semester** | **Autumn:** | | **Spring: Yes** | | |
|---|---|---|---|---|---|
| **III** | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 |
| **Prerequisite course code as per proposed course numbers** | | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

| **Text Books:** | | |
|---|---|---|
| 1 | Title | Quantum Computation and Quantum Information |
| | Author | M. A. Nielsen and I. Chuang |
| | Publisher | Cambridge University Press |
| | Edition | 2000 |
| 2 | Title | An Introduction to Quantum Computing Algorithms |
| | Author | Pittenger A. O. |
| | Publisher | Birkhauser |
| | Edition | 1999 |
| **Reference Book:** | | |
| 1 | Title | Quantum Computing for Everyone |
| | Author | C. Bernhardt |
| | Publisher | MIT Press |
| | Edition | 2019 |
| 2 | Title | Quantum Computing Explained |
| | Author | D. McMahon |

| | | |
|---|---|---|
| | Publisher | John Wiley & Sons |
| | Edition | 2008 |
| **Content** | **Unit** – 1 (9 Hours)<br>**Introduction to Quantum:** States, Wavefunction, Probability Density and probability, Steady State and Time-dependent, Superposition, Orthogonality and commutation<br><br>**Unit** – 2 (9 Hours)<br>**Quantum Physics & Mechanics:** Mixed states, Density matrix, composite systems and entanglement, Measurement and Uncertainty relations, tunneling and non-cloning<br><br>**Unit** – 3 (6 Hours)<br>**Quantum Circuits:** single-qubit gates, multiple qubit gates, design of quantum circuits.<br>**Quantum Information:** Comparison between classical and quantum information theory. Bell states. Quantum teleportation.<br><br>**Unit** – 4 (10 Hours)<br>**Quantum Algorithms:** Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search<br><br>**Unit** – 5 (6 Hours)<br>**Noise and error correction:** Graph states and codes, Quantum error correction, fault-tolerant computation. | |
| **Course Assessment** | Continuous Evaluation 25% | |
| | Mid Semester 25% | |
| | End Semester 50% | |

Course Matrix (CO-PO Mapping)

| COs | POs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | | | 2 | | | | | | | | 2 | 2 | |
| CO2 | 3 | 3 | 3 | 2 | | | 2 | | 2 | | 2 | 2 | 2 | 2 |
| CO3 | 3 | 2 | 3 | | 2 | | 2 | | 3 | | | 3 | 2 | 2 |
| CO4 | 3 | | 2 | | 2 | | 2 | | | | | 3 | 3 | |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

Lab Experiments:

| Exp. No. | List of Experiments |
|---|---|
| 1 | Develop circuits to execute on them with Python and Qiskit |
| 2 | Quantum Measurement |
| 3 | Accuracy of Quantum Phase Estimation |
| 4 | Iterative Quantum Phase Estimation |
| 5 | Scalable Shor's Algorithm |
| 6 | Grover's search with an unknown number of solutions |
| 7 | Quantum Simulation as a Search Algorithm |
| 8 | Quantum Error Correction |
| 9 | Solving the traveling sales problem using phase Estimation |
| 10 | QHED algorithm on small and large images |
| 11 | Quantum walk search algorithm |
| 12 | superdense coding |

| Course no: CSBM 616 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) |
|---|---|---|---|---|
| | NO | YES | NO | NO |
| **Type of course** | **Program Elective** | | | |
| **Course Title** | **Motion Analytics** | | | |
| **Course Coordinator** | | | | |
| **Course objectives:** | The course provides a comprehensive overview of clinical gait analysis to those who are relatively new to the field. The course will consist of a mixture of lectures, workshops and practical sessions that will allow participants to gain an understanding of walking pattern, and learn how to describe this in a systematic way. Different elements of three-dimensional, instrumented gait analysis will be covered in-depth, including kinematics, kinetics and electromyography. Real, clinical cases will be used to demonstrate how to interpret this data, as well as relating the findings back to clinical examination and patient history. | | | |
| **COs** | **CO1:** Explain term biomechanics and mention the mechanical aspects which are most relevant to motion analysis | | | **L1, L2** |
| | **CO2:** To implement the different methods of assessing force and pressure commonly used in research and clinical assessment | | | **L3, L4** |
| | **CO3:** To design a marker and marker less vision based gait analysis system | | | **L4, L5, L6** |
| | **CO4:** To implement machine learning techniques for gait analysis applications | | | **L3, L4** |

| **Semester** | **Autumn: Yes** | | **Spring: Yes** | | |
|---|---|---|---|---|---|
| **VI,VII** | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 60 |
| **Prerequisite course code as per proposed course numbers** | | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |
| **Text Books:** | | | | | |

| | | |
|---|---|---|
| 1 | Title | An Introduction to Gait Analysis |
| | Author | Michael W. Whittle |
| | Publisher | Elsevier |
| | Edition | 4th Edition. |
| 2 | Title | BIOMECHANICS AND MOTOR CONTROL OF HUMAN MOVEMENT |
| | Author | DAVID A. WINTER |
| | Publisher | Elsevier |
| | Edition | 4th Edition. |
| **Reference Books:** | | |
| 3 | Title | Biomechanics in Clinic and Research |
| | Author | Jim D Richards |
| | Publisher | Elsevier |
| | Edition | 1st Edition. |

**Content**

**Unit** – 1 (5 Hours)
Introduction to Mathematics and Bio- Mechanics: Trigonometry and Vector, Mechanics, Signal Processing

**Unit** – 2 (7 Hours)
Introduction to Bio-Motion Anatomy of Human Body, Motion Physiology, Bio-Mechanics, Human Gait,
Anthropometry in Bio-Motion, Walking and Gait Terminologies, Movement Analysis Methods (Vision Based Marker Based Motion Capture Marker Less Motion Capture) , Sensor Based, Other Techniques

**Unit** – 3 (8 Hours)
Kinematic: Conventions, Direct Measurement Techniques Goniometer, Imaging Measurement Techniques, Processing of Raw Kinematic, Other Kinematic Variables
Kinetic: Forces and Momentum of Force, Biomechanical Models, Free body Diagram, Force Transducers and force Plates, EMG based motion analysis

**Unit**- 4 (8 hour)
Model of Human Pose and Motion:
Object Detection, Semantic Segmentation, Instance Segmentation,
Traditional Object Detectors methods, SIFT, HOG, BOW
Advance Object detectors, Landmark detection, Sliding windows detection – Bounding box predictions, YOLO, Anchor boxes, Evaluating object localization

Human Body Representation, Traditional Methods: Latent Variable Models- PCA, FA, etc., Discriminative Model: Regression, Generative Model: Kalmann Filter, Partial Filter

| | |
|---|---|
| | **Unit** –5 (8 Hours)<br>Motion Modelling and Synthesis using ML Approaches:<br>Neural Network, Motion Graph Inverse Kinematics Latent Variable, Supervised Techniques, Unsupervised Techniques, Reinforcement Techniques, Human Motion Classification Methods<br><br>Gait Analysis Applications<br>Clinical Analysis, Sports Analysis, Biometric Gait, Gait Rehabilitation , Control Applications, Bipedal Robotics : introduction and methods |
| **Course Assessment** | Continuous Evaluation 25% |
| | Mid Semester 25% |
| | End Semester 50% |

**List of Lab Experiments:**

1. Python Frameworks Tutorial (with Jupyter and Colab) and it's Data Structures
2. Introduction to Python libraries for Data Analysis (Pandas, NumPy, Matplotlib)
3. Data Collection & Creation Using Web Scraping- Static and Dynamic Webpages
4. Exploratory Data Analytics and Feature Engineering
5. Vision based gait analysis system using passive markers ; Identifying the markers positions (in an image)
6. Feature Engineering using video; Marker Detection and Classification [M1-M5]; Gap filtering the occluded frames.
7. Kinematic Parameters Estimation: Knee Angle (Passive Markers ;)
8. Human Detection and Marker based system occlusions : Regression
9. Marker less Gait Analysis (Kinematic Parameters Extraction) using OpenPose
10. Application of Traditional Computational Techniques in Kinetic Analysis, Biometric Gait, Sports Analysis, Bipedal gait

Course Matrix (CO-PO-PSO Mapping)

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO 1 | **3** | **2** | | | | | | | | | | | **1** | **2** |
| CO 2 | **2** | **2** | **3** | **3** | **3** | | | | | | | | **3** | **3** |
| CO 3 | **2** | **2** | **3** | **3** | **3** | | | | | | | | **3** | **3** |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 4 | **2** | **2** | **3** | **3** | **3** | | | | | | | | **3** | **3** |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSLM 625 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | NO | YES | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Elective** |
| **Course Title** | **Soft Computing** |
| **Course objectives:** | The objective of this course is to provide an introduction to the basic principles, techniques, and applications of soft computing and provide mathematical background related to Soft Computing including Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms. |
| **Course Outcomes:** | ● Define the basic concepts of soft computing (L2, L3).<br>● Explain applications & operations of Fuzzy Logic in real life Problems (L4, L5).<br>● Apply different FIS models to solve optimization problems. Analyse and examine Evolutionary and swarm algorithms in solving real world multi-Objective optimization problems (L2, L3, L4).<br>● Choose of different optimization algorithms to solve real-life multi objective problems and Discuss applications of Soft Computing and solve Problems in Varieties of Application Domains (L5, L6). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 0 | 3 | 36 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | A comprehensive foundation. Neural Networks |
| | Author | Simon Haykin |
| | Publisher | Pearson |
| | Edition | Second Edition, 2001 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Fuzzy logic with engineering applications |

| | | |
|---|---|---|
| | Author | Timothy J. Ross |
| | Publisher | John Wiley & Sons |
| | Edition | Third Edition, 2009 |
| 2. | Title | An Introduction to Genetic Algorithms |
| | Author | Melanie Mitchell |
| | Publisher | Prentice-Hall |
| | Edition | 1998 |
| 3. | Title | Genetic Algorithms in Search, Optimization, and Machine Learning |
| | Author | D. E. Goldberg |
| | Publisher | Addison-Wesley |
| | Edition | 1989 |
| 4. | Title | Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications |
| | Author | S. V. Kartalopoulos |
| | Publisher | IEEE Press |
| | Edition | PHI, 2014 |
| 5. | Title | Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications |
| | Author | S. Rajasekaran & G. A. Vijayalakshmi Pai |
| | Publisher | PHI |
| | Edition | 2003 |
| 6. | Title | Principles of Soft Computing |
| | Author | S. N. Sivanandam & S. N. Deepa |
| | Publisher | Wiley - India |
| | Edition | Second Edition, 2007 |

**Content**

**Unit I: Introduction (6 Hours)**

Basic mathematics of soft computing, Learning and statistical approach to regression and classification.

**Unit II: Neural Networks and SVM** (8 Hours)

Single layer perceptron, ADALINE, LMS algorithm, Multi layer perceptron, Radial basis function, Associative Memory Networks, Hopfield Network, Principal component analysis, RNN, MATLAB Programming. Introduction to SVM, Binary classification, Regression by SVM: linear & nonlinear, Decomposing multiclass classification into binary classification. SVM MATLAB Applications

**Unit III: Fuzzy Logic** (8 Hours)

Introduction to Fuzzy logic, Probability vs Possibility Theory, Classical set and fuzzy set, fuzzy set operations, Criteria for Selecting appropriate aggregation Operators. Fuzzy relation, Fuzzy composition, Fuzzy Inference system, Fuzzification, rule based , Defuzzification, Fuzzy Arithmetic, Fuzzy logic

| | |
|---|---|
| | application<br><br>**Unit IV: Hybrid Intelligent System: Neuro-Fuzzy** (8 Hours)<br>Introduction, Models of Neuro-fuzzy system (NFS), Interpretation of NFS layers, Adaptive N-F Inference system (ANFIS) Architecture, T-S Fuzzy system, Mamdani Fuzzy System, ANFIS MATLAB Applications<br><br>**Unit V: Optimization Techniques** (6 Hours)<br>Introduction to Optimization, Genetic algorithms, Procedure and working of GA, Particle swarm optimization, Matlab programming. |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | | | | | | | | | | 2 | 2 |
| CO2 | 2 | 2 | 2 | | 2 | | | | | | | | 2 | 2 |
| CO3 | 3 | 2 | 2 | | 2 | 2 | | | | | | | 2 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | 2 | 2 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSBM 662 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES/NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | NO | YES | NO | NO | NO |

| | |
|---|---|
| **Type of course** | **Program Elective** |
| **Course Title** | **Distributed Databases** |
| **Course objectives:** | Introduce Distributed data management technologies that go beyond traditional (relational) database management systems and enable students to evaluate the advantages and disadvantages of such technologies in different application contexts. |
| **Course Outcomes:** | ● Study and understand distributed DBMS architecture and distributed database concepts (L1, L2).<br>● Identify and apply various stages of distributed query processing (L2, L3).<br>● Analyse and evaluate distributed transaction processing, distributed concurrency control, and distributed reliability (L4, L5).<br>● Learn NoSQL databases, their types and applicability in different domains (L2, L3). |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 2 | 4 | 36 + 18 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Distributed Databases: Principles and Systems |
| | Author | Stefano Ceri, Giuseppe Pelagatti |
| | Publisher | Tata McGraw-Hill Education |
| | Edition | Indian Edition, 15th Reprint 2018 |
| 2. | Title | Principles of Distributed Database Systems |
| | Author | M. Tamer Ozsu, Patrick Valduriez |
| | Publisher | Springer |
| | Edition | Fourth Edition |

| | | |
|---|---|---|
| 3. | Title | NoSQL for Mere Mortals |
| | Author | Dan Sullivan |
| | Publisher | Addison-Wesley Professional |
| | Edition | Indian Edition, published 2015. |
| **Reference Book:** | | |
| 1. | Title | Distributed Database Management Systems: A Practical Approach |
| | Author | Saeed K. Rahimi, Frank S. Haug |
| | Publisher | John Wiley & Sons |
| | Edition | 2010 |
| 2. | Title | Professional NoSQL |
| | Author | Shashank Tiwari |
| | Publisher | Wiley |
| | Edition | 2011 |
| 3. | Title | NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence |
| | Author | Pramod Sadalage, Martin Fowler |
| | Publisher | Addison-Wesley |
| | Edition | 2013 |
| 4. | Title | Administering Oracle |
| | Author | Ivan Bayros |
| | Publisher | BPB Publications |
| | Edition | 2006 |

**Content**

### Unit I: Introduction to Distributed Databases (06 Hours)

Introduction to Distributed Databases, Promises of DDBSs, Design, Issues, Distributed DBMS Architecture.

### Unit II: Distributed Database Design (08 Hours)

Distributed Database Design: Design strategies (Top-down, Bottom-up), Design Issues, Data Fragmentation (Horizontal, Vertical, Hybrid), Allocation and Replication.

### Unit III: Distributed Query Processing (10 Hours)

Distributed Query Processing: Overview, Objectives, Layers, Query Decomposition, Data Localization, Distributed Query Optimization, Distributed Query Execution.

### Unit IV: Transaction and Concurrency Control in Distributed Databases (08 Hours)

Distributed Transaction Processing, Distributed Concurrency Control, Distributed DBMS Reliability.

| | |
|---|---|
| | **Unit V: NoSQL Databases and its Types (08 Hours)**<br>Different types of NoSQL Databases:Key-value Stores, Wide –column Stores, Document Stores, Graph Stores.<br><br>**List of Experiments:**<br>1. Create two databases on single DBMS and design database to horizontal fragment and share the fragments from both databases.<br>2. Create two databases on single DBMS and design database to vertical fragment.<br>3. Create two databases on single DBMS and design database to hybrid fragment and share the fragments from both database and write single query for creating view.<br>4. Working with Database Link in Oracle: create a Database Link with UserName and Password and create a Database Link without UserName and Password.<br>5. Write the code to create a private database link that points to the remote database named Employee and retrieve information from Employee.<br>6. Write the code to create a public database link, pub_emp_link that points to the remote database named Employee and retrieve information from Employee.<br>7. Write the code to create a global database link using Oracle Net Manager.<br>8. Write a Program to implement of Lamport's Logical Clock<br>9. Case study on NoSQL |
| **Course Assessment** | **THEORY Evaluation**:<br>• Continuous Evaluation: 25%<br>• Mid Semester: 25%<br>• End Semester: 50% |
| | **LAB Evaluation**:<br>• Continuous Evaluation: 50%<br>• End Term Evaluation: 50% |
| | **Final Evaluation**: 60% of Theory + 40% of Lab |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | | 1 | 1 | | 3 | 1 | | | | | 3 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 1 | | | | 1 | 1 | 2 | 3 | 2 |
| CO3 | 1 | | 2 | 1 | 3 | 2 | 2 | 2 | 1 | 2 | | 3 | 3 | 2 |
| CO4 | 2 | 2 | 2 | 3 | 1 | 2 | | | | | 2 | 2 | 3 | 1 |

1=addressed to small extent
2= addressed significantly
3= addressed strongly (major part of course)

| Course no: CSLM 673 | PC (YES/NO) | PE (YES/NO) | IS-TP(YES /NO) | SEM (YES/NO) | TH-DIS (YES/NO) |
|---|---|---|---|---|---|
| | NO | YES | NO | NO | NO |
| **Type of course** | **Program Elective** | | | | |
| **Course Title** | **Wireless Sensor Networks** | | | | |
| **Course Coordinator** | | | | | |

| | |
|---|---|
| **Course objectives:** | ● To understand the role and functions of wireless sensor networks and enabling technologies.<br>● To understand the concept of WSN coverage management.<br>● To understand the concepts of MAC address assignment in WSN, and security issues.<br>● To gain hands-on experience with the design and implementation of WSNs through programming. |
| **Course Outcomes:** | ● Describe the overview of wireless sensor networks and its enabling technologies (L1, L2).<br>● Understand the WSN coverage and Topology management (L1, L2).<br>● Apply WSN concepts for assignment of MAC addresses and understand the need of WSN security (L2, L3).<br>● Analyze the sensor network platform and tools state-centric programming (L3, L4). |
| **POs** | |

| | **Autumn:** | | **Spring:** | | |
|---|---|---|---|---|---|
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** |
| **Contact Hours** | 3 | 0 | 0 | 3 | 40 |
| **Prerequisite course code as per proposed course numbers** | NIL | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

**Text Books:**

| | | |
|---|---|---|
| 1. | Title | Protocols And Architectures for Wireless Sensor Networks |
| | Author | Holger Karl, Andreas Willig |
| | Publisher | John Wiley |
| | Edition | 2005 |
| 2. | Title | Fundamentals Of Wireless Sensor Networks - Theory And Practice |
| | Author | Waltenegus Dargie, Christian Poellabauer |
| | Publisher | John Wiley & Sons Publications |
| | Edition | 2011 |

**Reference Book:**

| | | |
|---|---|---|
| 1. | Title | Wireless Sensor Networks |
| | Author | Ian F. Akyildiz, Mehmet Can Vuran |
| | Publisher | John Wiley & Sons |

| | | |
|---|---|---|
| | Edition | First Edition, 2011 |
| 2. | Title | Wireless Sensor Network Designs |
| | Author | Anna Hac |
| | Publisher | John Wiley & Sons, |
| | Edition | First Edition, 2013 |
| **Content** | **Unit I: Introduction to Wireless Sensor Network (8 Hours)**<br>Wireless Sensor Network (WSN) Architecture and protocol stack, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Factors affecting WSN design, Applications of WSNs.<br>**Unit II: WSN Coverage Area (8 Hours)**<br>Area coverage, Point Coverage, Barrier Coverage, Coverage Maintenance, Sensor Placement, Topology Management in WSN, Types of WSN, WSN Algorithms, MANETs.<br>**Unit III: Networking (8 Hours)**<br>MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts - SMAC, B-MAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols Energy- Efficient Routing, Geographic Routing, Congestion and Flow Control in Wireless Sensor Networks..<br>**Unit IV: Security (8 Hours)**<br>Need of Security in Wireless Sensor Networks, Types of Keying Mechanisms for WSN, Security requirement in WSN, WSN attacks, and Security protocols for WSNs.<br>**Unit V: Platforms and Tools (7 Hours)**<br>Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node level Simulators, State-centric programming. | |
| **Course Assessment** | **THEORY Evaluation**:<br>● Continuous Evaluation: 25%<br>● Mid Semester: 25%<br>● End Semester: 50% | |

**Course Matrix (CO-PO-PSO Mapping)**:

| COs | POs & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | **2** | | | | | **2** | | | | **2** | | **2** | **1** | |
| CO2 | **2** | **2** | **2** | | | | | | | | | | | **3** |
| CO3 | **3** | | | | **2** | | | | | **2** | | | **2** | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | | **2** | | | **2** | | | **2** | | **2** | | | **2** | |

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3= addressed strongly (major part of course)

| Course Code: CSLM 620 | PC (YES/ NO) | PE (YES/ NO) | OE (YES/ NO) | AS (YES/ NO) | HM (YES/ NO) | ST-IS-PR (YES/ NO) | AE (YES / NO) |
|---|---|---|---|---|---|---|---|
| | NO | YES | NO | NO | NO | NO | NO |
| Type of course | Program Elective | | | | | | |
| Course Title | NATURAL LANGUAGE PROCESSING | | | | | | |
| Course Objectives | To provide a broad introduction to NLP with a particular emphasis on core algorithms, data structures, and machine learning for NLP, text classification, sentiment analysis and other applications of NLP | | | | | | |
| Course Outcomes | **CO1**: Understand the fundamental concepts of natural language processing, including models, ambiguity, processing paradigms, and phases of NLP along with text representation in computers. | | | | | **L1, L2, L3** | |
| | **CO2**: Apply linguistic resources and tools such as corpus, WordNet, TreeBank, and Finite State Automata to analyze morphology and word recognition using probabilistic models like N-grams and HMM. | | | | | **L4, L5, L6** | |
| | **CO3**: Demonstrate the ability to perform Part-of-Speech tagging, statistical and probabilistic parsing, and handle challenges like unknown words and multi-word expressions. | | | | | **L4, L5, L6** | |
| | **CO4**: Evaluate semantic analysis techniques, Word Sense Disambiguation methods, and NLP applications such as sentiment analysis, summarization, and machine translation. | | | | | **L4, L5, L6** | |
| Semester | **Autumn: Yes** | | | **Spring:** | | | |
| | **Lecture** | **Tutorial** | **Practical** | **Credits** | **Total teaching hours** | | |
| Contact Hours | **3** | **0** | **0** | **3** | **36** | | |

| | | | | | |
|---|---|---|---|---|---|
| **Prerequisite course code as per proposed course numbers** | **Machine Learning** | | | | |
| **Prerequisite credits** | NIL | | | | |
| **Equivalent course codes as per proposed course and old course** | NIL | | | | |
| **Overlap course codes as per proposed course numbers** | NIL | | | | |

| | | |
|---|---|---|
| **TextBooks** | | |
| 1 | Title | Speech and Language Processing |
| | Author | Daniel Jurafsky and James H Martin |
| | Publisher | Pearson Education |
| | Edition | 2009 |
| **Reference Books** | | |
| 1 | Title | Natural language processing and Information retrieval |
| | Author | Siddiqui T., Tiwary U. S. |
| | Publisher | OUP |
| | Edition | 2008 |
| 2 | Title | Natural language Understanding |
| | Author | James A |
| | Publisher | Pearson Education |
| | Edition | 1994 |
| 3 | Title | Natural language processing: a Paninian perspective |
| | Author | Bharati A., Sangal R., Chaitanya V. |

| | | |
|---|---|---|
| | Publisher | PHI |
| | Edition | 2000 |
| **Content** | **Unit 1: Introduction to Natural Language Processing**<br>Introduction Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. Text representation in computers.<br><br>**Unit 2: Linguistic Resources and Statistical Foundations**<br>Linguistics resources Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Regular expressions, Finite State Automata, word recognition, lexicon. Morphology, acquisition models, Finite State Transducer. N grams, smoothing, entropy, HMM, Maximum Entropy.<br><br>**Unit 3: POS Tagging and Parsing Techniques**<br>Part of Speech tagging Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions. Parsing Statistical Parsing, Probabilistic parsing.<br><br>**Unit 4: Semantics and Text Analysis**<br>Semantics Meaning representation, semantic analysis, lexical semantics, WordNet, Word Sense Disambiguation, Selectional restriction, machine learning approaches, dictionary based approaches. Text Classification Sentiment Analysis.<br><br>**Unit 5: NLP Applications**<br>Applications of NLP Spell checking, text summarization, machine translation, chatbots, question answering, text generation, speech-based systems, named entity recognition, and topic modeling. | |
| **Course Assessment** | Continuous Evaluation | |
| | Mid Semester | |
| | End Semester | |

**Course Matrix (CO-PO-PSO Mapping)**

| COs | POs s & PSOs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | | | 2 | | | | | | | 1 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | | | | | | | 1 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | | | | | | | 1 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 3 | 3 | | | | | | | 2 | 3 | 3 |

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