Course Curriculum for M Tech in Computer Science and Engineering

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, AI&DS, MCA 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

2.1 Preamble

M. Tech. Computer Science and Engineering: The objective of the M. Tech program in Computer Science and Engineering (CSE) 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. To give due importance to applied as well as theoretical aspects of computing, the curriculum for the MTech (CSE) program covers most of the foundational aspects of computing sciences and 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 M. Tech 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.
- In the proposed PG scheme the CSE department is proposing in 05 different following specializations
  1. *Artificial Intelligence and Machine Learning* (Bouquet 1)
  2. *Data Science* (Bouquet 2)
  3. *Information Security* (Bouquet 3)
  4. *Computer Systems* (Bouquet 4)
  5. *Networks and Distributed Systems* (Bouquet 5)

- Total 5 electives are proposed in the complete PG program among them at least 4 electives are required from a bouquet to get the specialization (with the respective bouquet) with M. Tech in Computer Science and Engineering.
- Students can attend 2 MOOC/NPTEL/any online courses (as per department list) among the proposed 5 electives and the evaluation will be done by the Department as per Academic Calendar and prevailing norms.
- 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)

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)

PEO-1	Post Graduates will establish themselves as learned professionals by resolving complex computational problems and developing effective solutions working collaboratively in multidisciplinary teams, contributing their expertise.
PEO-2	Post Graduates will demonstrate a strong computer science and engineering foundation for implementing research and product development in core computer systems.
PEO-3	Post Graduates shall drive scientific and societal advancement through technological innovation and entrepreneurship.

PEO-4	Post Graduates will demonstrate effective teamwork and leadership skills along diverse career paths, encouraging professional ethics and active participation needed for a successful career.

2.5 Program Specific Outcomes (PSOs)

PSO-1	Post Graduates will be proficient in analyzing complex computational problems and devising efficient solutions using advanced algorithms, data structures, and computational techniques.
PSO-2	Ability to practice as an ethical Computer Science Engineer or Researcher by employing soft and project management skills learned through internships, project work, and collaborative projects with industry with the capability to adapt to new and emerging technologies, frameworks, and tools, keeping their skills and knowledge up to date.

3.1 Semester wise Credit Structure

Credits						**Total**
Sl. No.	**Courses**	**1st Year**		**2nd Year**		
		1st Sem	**2nd Sem**	**3rd Sem**	**4th Sem**	
1	Program Core (PC)	11	11	-	-	22
2	Program Electives (PE)	7	7	3	3	20
3	Independent Study / Term Paper (IS-TP)	2	2			4
4	Seminar (SEM)			1	1	2
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	CSBM 502	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 553	Cryptography and Digital Security	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	CSLM 611	Machine Learning	3	0	0	3		19	CSLM 634	Information Security and Privacy	3	0	0	3
2	CSBM 612	Deep Learning and Applications	3	0	2	4		20	CSLM 636	Time Series Analysis	3	0	0	3
3	CSBM 613	Artificial Intelligence for Robotics	3	0	2	4		21	CSLM 653	Introduction to Cyber Security	3	0	0	3

4	CSBM 614	Quantum Computing	3	0	2	4
5	CSBM 615	Advanced Digital Image Processing	3	0	2	4
6	CSLM 616	Motion Analytics	3	0	0	3
7	CSBM 617	Data Handling & Visualization	3	0	2	4
8	CSLM 618	Optimization Techniques	3	0	0	3
9	CSLM 619	Game Theory	3	1	0	4
10	CSLM 620	Natural Language Processing	3	0	0	3
11	CSLM 621	Reinforcement Learning & Applications	3	0	0	3
12	CSLM 622	Information Retrieval	3	0	0	3
13	CSLM 623	Fuzzy Logic and applications	3	0	0	3
14	CSLM 624	Social Network Analysis	3	0	0	3
15	CSLM 625	Soft Computing	3	0	0	3
16	CSBM 631	Cloud Computing	3	0	2	4
17	CSBM 632	Internet of Things	3	0	2	4
18	CSLM 633	Big Data Analytics	3	0	0	3
22	CSLM 654	Database and online Social Media Security	3	0	0	3
23	CSLM 661	Advanced Computer Networks	3	0	0	3
24	CSBM 662	Distributed Databases	3	0	2	4
25	CSBM 663	Simulation and Modelling	3	0	2	4
26	CSLM 664	Randomized Algorithms	3	1	0	4
27	CSLM 665	Parallel Algorithms	3	0	0	3
28	CSLM 666	Computational Complexity	3	1	0	4
29	CSBM 671	Network and Wireless Security	3	0	2	4
30	CSLM 672	Queueing Theory	3	1	0	4
31	CSLM 673	Wireless Sensor Networks	3	0	0	3
32	CSLM 674	Next Generation Networks	3	0	0	3
33	CSLM 675	Mobile Computing	3	0	0	3
34	CSBM 678	Network and Data Security	3	0	2	4
35	CSLM 677	Information Theory and Coding	3	0	0	3

III. Elective Courses

Bouquet 1 [Specialization in AI and ML]

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	0	3		9	CSLM 619	Game Theory	3	1	0	4
2	CSBM 612	Deep Learning and Applications	3	0	2	4		10	CSLM 620	Natural Language Processing	3	0	0	3
3	CSBM 613	Artificial Intelligence for Robotics	3	0	2	4		11	CSLM 621	Reinforcement Learning & Applications	3	0	0	3
4	CSBM 614	Quantum Computing	3	0	2	4		12	CSLM 622	Information Retrieval	3	0	0	3
5	CSBM 615	Advanced Digital Image Processing	3	0	2	4		13	CSLM 623	Fuzzy Logic and applications	3	0	0	3
6	CSBM 616	Motion Analytics	3	0	0	3		14	CSLM 624	Social Network Analysis	3	0	0	3
7	CSBM 617	Data Handling & Visualization	3	0	2	4		15	CSLM 625	Soft Computing	3	0	0	3
8	CSLM 618	Optimization Techniques	3	0	0	3								

Bouquet 2 [Specialization in Data Science]

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	0	3		7	CSBM 634	Information Security and Privacy	3	0	0	3
2	CSBM 612	Deep Learning and Applications	3	0	2	4		8	CSLM 618	Optimization Techniques	3	0	0	3
3	CSBM 617	Data Handling & Visualization	3	0	2	4		9	CSLM 619	Game Theory	3	1	0	4
4	CSBM 631	Cloud Computing	3	0	2	4		10	CSLM 624	Social Network Analysis	3	0	0	3
5	CSBM 632	Internet of Things	3	0	2	4		11	CSLM 636	Time Series Analysis	3	0	0	3
6	CSBM 633	Big Data Analytics	3	0	0	3								

Bouquet 3 [Specialization in Information Security]

S. No.	Course Code	Course Name	L	T	P	C		S. No.	Course Code	Course Name	L	T	P	C
1	CSBM 634	Information Security and Privacy	3	0	0	3		3	CSLM 653	Introduction to Cyber Security	3	0	0	3
2	CSBM 678	Network and Data Security	3	0	2	4		4	CSLM 654	Database and online Social Media Security	3	0	0	3

Bouquet 4 [Specialization in Computer Systems]

S. No.	Course Code	Course Name	L	T	P	C		S. No.	Course Code	Course Name	L	T	P	C
1	CSBM 661	Advanced Computer Networks	3	0	0	3		4	CSLM 664	Randomized Algorithms	3	1	0	4
2	CSBM 662	Distributed Databases	3	0	2	4		5	CSLM 665	Parallel Algorithms	3	0	0	3
3	CSBM 663	Simulation and Modelling	3	0	2	4		6	CSLM 666	Computational Complexity	3	1	0	4

Bouquet 5 [Specialization in Networks and Distributed Systems]

S. No.	Course Code	Course Name	L	T	P	C		S. No.	Course Code	Course Name	L	T	P	C
1	CSBM 614	Quantum Computing	3	0	2	4		9	CSLM 672	Queueing Theory	3	1	0	4
2	CSBM 631	Cloud Computing	3	0	2	4		10	CSLM 673	Wireless Sensor Networks	3	0	0	3
3	CSBM 632	Internet of Things	3	0	2	4		11	CSLM 674	Next Generation Networks	3	0	0	3
4	CSBM 633	Big Data Analytics	3	0	2	4		12	CSLM 675	Mobile Computing	3	0	0	3
5	CSBM 661	Advanced Computer Networks	3	0	0	3		13	CSLM 677	Information Theory and Coding	3	0	0	3
6	CSBM 671	Network and Wireless Security	3	0	2	4								
7	CSLM 619	Game Theory	3	1	0	4								

Course Title: Computational Mathematics

Course Code: CSLM 501

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	To introduce the concepts of probability.
CO-2	To understand the concepts of expectations and moment generating functions.
CO-3	To introduce hypothesis and its various testing.
CO-4	To understand the concept of Markov process.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	1					1	
CO2	1	1	2			2	
CO3	1	2	2	2	2	2	2
CO4	2	2	2	2	1	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I: Introduction to Probability (7 Hours)
The concept of probability, The axioms of probability, Some important theorems on Probability, Conditional Probability, Theorems on conditional probability, Independent Event's, Bayes' Theorem.

Unit II: Random variables and probability distributions (8 Hours)
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 Definition, Functions of random variables, some theorems on Expectation, the variance and Standard Deviation, Moments, Moment Generating Functions, Covariance, Correlation Coefficient.

Unit III: Sampling Theory (7 Hours)
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.

Unit IV: Markov Chains (7 Hours)
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.

Unit V: Statistics (7 Hours)
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.

Learning Resources:

Text Books:
[T1] Papoulis, Athanasios, and S.Unnikrishna Pillai, *"Probability, random variables, and stochastic processes"*, Tata McGraw Hill Education, 2002.
[T2] Sheldon M. Ross, *"Introduction to Probability and Statistics for Engineers and Scientists"*, Elsevier, Fifth Edition.

Reference Books:
[R1] Robert V. Hogg, Joseph McKean, Allen T. Craig, *"Introduction to Mathematical Statistics"*, Pearson, Seventh Edition.

Course Title: Advanced Data Structure and Algorithms

Course Code: CSBM 502

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Analyze the complexity of algorithms and apply asymptotic notations.
CO-2	Study of nonlinear data structure and applications.
CO-3	Study of Amortized algorithms.
CO-4	Understand and apply greedy dynamic and divide and conquer.
CO-5	Study of randomized and approximation algorithms.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	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 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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, Knap Sack Problem. Parallel Algorithm and External Memory Algorithm.

Learning Resources:

<u>Text Books:</u>

[T1] J. Kleinberg and E. Tardos, *"Algorithm Design"*, Addison Wesley, 2005.
[T2] TH. Cormen, CE. Leiserson, RL. Rivest and C. Stein, *"Introduction to Algorithms"*, MIT Press, 2001.

<u>Reference Books:</u>

[R1] Aho, JE Hopcroft and J.D. Ullman, *"The Design and Analysis of Computer Algorithms"*, Addison Wesley, 1974.
[R2] S Sahni, *"Data Structures, Algorithms and Applications in C++"*, McGraw Hill, 2001.
[R3] M.T. Goodrich and R. Tamassia, *"Algorithm Design: Foundations, Analysis and Internet Examples"*, John Wiley & Sons, 2001.

<u>Other Suggested Readings:</u>

<u>List of Experiments:</u>

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
8. Study and implementation of KMP Algorithm and Union by rank algorithm
9. Study and implementation of Path compression
10. Study of Research paper

Course Title: Advanced Databases

Course Code: CSBM 503

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Understand Big Data types and models, identify storage complexities, and apply concepts to real-world scenarios like Online social media and E-commerce Sites.
CO-2	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.
CO-3	Understand and apply R for data analytics, integrate with databases and business intelligence systems, and derive insights from datasets for informed decision-making.
CO-4	Implement semi-structured databases and its evaluation with emerging databases.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	1	3	1		2	2
CO2	3	2	2		1	2	3
CO3	2	3	3	1		1	2
CO4	3	2	3		2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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.

Learning Resources:

Text Books:

[T1] Henry F Korth, Abraham Silberschatz, S. Sudurshan, *"Database System Concepts"*, McGraw-Hill, Sixth Edition, 2011.
[T2] Ramez Elmasri, Shamkant B. Navathe, *"Fundamentals of Database Systems"*, Pearson Education, Seventh Edition, 2015.

Reference Books:

[R1] Thomas Connolly, Carolyn Begg, *"Database Systems-A Practical Approach to design, Implementation and Management"*, Addison Wesley, Sixth Edition, 2015.
[R2] Tom Plunkett, Brian Macdonald, Bruce Nelson, Mark Hornick, Helen Sun, Khader Mohiuddin, Debra Harding, Gokula Mishra, Robert Stackowiak, Keith Laker and David Segleau, *"Oracle Big Data Handbook"*, McGraw Hill, First Edition, 2013.
[R3] Seema Acharya, *"Data Analytics using R"*, McGraw-Hill, First Edition, 2013.

Other Suggested Readings:

List of Experiments:

1. Advanced concepts of row-oriented databases and performing operations like schema creation, indexing, and views.
2. Install a column-oriented database and make a step-by-step installation guide.
3. Perform various operations like schema creation, indexing, and views for column-oriented databases.
4. Query Execution Time Based Comparison Between Row-Oriented Database and Column-Oriented Database.
5. Explore Physical level storage structure of Postgres DB.
6. Explore R and perform various tasks like Installation, Connection, Basic Create, and Insert.
7. Perform operations like import and export using R into a row-oriented database.
8. Create the XSD from the XML documents and validate them.
9. Write queries in XQuery on different scenarios like Bibliography, Bank, and Company.
10. Write XML queries based on different use-case scenarios.

Course Title: Data Mining and Warehousing

Course Code: CSBM 505

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain the concept and significance of Data Mining.
CO-2	Explore Recent Trends in Data Mining such as Web Mining, Spatial-Temporal Mining.
CO-3	Analyze different mining algorithms and clustering techniques for Data Analytics.
CO-4	Design and Develop a Data Warehouse for an organization.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	1	2	1		2	2
CO2	3	2	2		1	2	2
CO3	2	3	2	2		1	2
CO4	3	2	3		2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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 Mining 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 item sets, closed item sets, association rules, Types of association rule (Single dimensional, multi-dimensional, multilevel, quantitative), Finding frequent item set (Apriori algorithm, FP growth), Generating association rules from frequent item set, 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)
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.

Learning Resources:

Text Books:
[T1] Jiawei Han and Micheline Kamber, *"Data Mining Concepts and Techniques"*, Morgan Kaufmann, 2011.
[T2] Eibe Frank and Ian H. Witten, *"Data Mining: Practical Machine Learning Tools and Techniques"*, Morgan Kaufmann, Third Edition,2011.
[T3] Pang-Ning Tan Michael Steinbach Vipin Kumar, *"Introduction to Data Mining"*, Pearson, Second Edition, 2016.

Reference Books:
[R1] Abraham Sibertschatz, Henry F. Korth and S. Sudarshan, *"Database Concepts"*, McGraw Hill, Seventh Edition, 2019.

Other Suggested Readings:

List of Experiments:

1. Load Data from heterogenous sources including text files into a predefined warehouse schema.
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.
3. Feature Selection and Variable Filtering (For very large datasets).
4. Association Mining in large datasets.
5. Interactive Drill-Down, Rollup, Slice and Dice Operations.
6. Generalized E Mandk – Means Cluster Analysis.
7. Generalized Additive Models (GAM).
8. General Classification Regression Tress (GTrees)
9. General CHAID (Chi- square Automatic Interaction Detection) Models.
10. Interactive Classification and Regression Trees.
11. Goodness of Fit Computations.

Course Title: Networking and Communication

Course Code: CSBM 551

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Analyze advanced network architectures, protocols, and performance issues in modern communication systems.
CO-2	Evaluate routing, congestion control, and Quality of Service (QoS) in large-scale networks.
CO-3	Design and assess software-defined, virtualized, wireless, and data-center networking solutions for emerging applications.
CO-4	Assess emerging communication technologies in 5G/6G and propose solutions for future networking challenges.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	3	3	3	1	2	2
CO2	3	3	3	3	1	2	2
CO3	3	3	3	3	1	1	2
CO4	3	3	3	3	1	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module-1 Advanced Network Architecture and Performance Analysis: Internet architecture evolution, Next Generation Networks (NGN), Internet of Everything (IoE), Advanced Network Models- Overlay and underlay networks, Cross-layer design, Traffic Characterization- Traffic models, Self-similar traffic, Network measurement techniques, Performance Analysis - Delay, throughput, jitter, packet loss, Queueing theory fundamentals, Little's theorem, M/M/1 and M/M/m models. **[08]**

Module-II Routing, QoS and Traffic Engineering: Advanced Routing Protocols- OSPF optimization, IS-IS architecture, BGP and inter-domain routing, Segment Routing, Traffic Engineering - MPLS architecture, MPLS traffic engineering, Constraint-based routing, Resource reservation techniques, Quality of Service - QoS metrics, Integrated Services (IntServ), Differentiated Services (DiffServ), Congestion Control - TCP congestion control evolution, High-speed TCP variants, Active Queue Management, Multicast and Anycast Communication - Multicast routing, Application-layer multicast. **[10]**

Module-III Software Defined Networking and Network Virtualization: Software Defined Networking - SDN architecture, Control plane and data plane separation, OpenFlow protocol, SDN controllers, AI-enabled SDN, Network Function Virtualization - Virtual network functions, Service function chaining, Virtualized network infrastructure, Data Center Networks - Data center architectures, Fat-tree topology, Clos networks, Spine-leaf architecture. **[8]**

Module-IV Next Generation Wireless Communication: 5G Network Architecture - 5G core network, Network slicing, Mobile Edge Computing, Beyond 5G and 6G - Intelligent communication systems, Integrated sensing and communication, AI-native networks **[8]**

Learning Resources:

Text Books:

[T1] Andrew S. Tanenbaum, David J. Wetherall, *"Computer Networks"*, Pearson Education, 2010.
[T2] Thomas D. Nadeau, Ken Gray, *"Software Defined Networks: A Comprehensive Approach"*, Morgan Kaufmann, 2016.
[T3] Afif Osseiran, Jose F. Monserrat, Patrick Marsch, *"5G Mobile and Wireless Communications Technology"*, Cambridge University Press, 2016.

Reference Books:

[R1] Dimitri P. Bertsekas, Robert G. Gallager, *"Data Networks"*, Prentice Hall, 2017.

Other Suggested Readings:

List of Experiments:

1. Traffic analysis using Wireshark.
2. OSPF and BGP configuration using GNS3/EVE-NG.
3. MPLS traffic engineering simulation.
4. QoS implementation and performance analysis.
5. SDN controller deployment using Mininet and OpenDaylight/Ryu.
6. OpenFlow rule implementation.
7. Data center network simulation.
8. Container networking using Docker and Kubernetes.
9. LTE/5G network simulation using ns-3.
10. Research mini-project on AI-enabled networking.

Course Title: Advanced Artificial Intelligence

Course Code: CSBM 552

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Understand the basic concepts of AI.
CO-2	Apply search strategies to solve AI problems.
CO-3	Apply knowledge representation and reasoning to solve real world AI Problems.
CO-4	Explore machine learning concepts and algorithms for real world applications.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	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 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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 Free space 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 overtime, 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, Naïve 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.

Learning Resources:

Text Books:

[T1] Stuart Russell, Peter Norvig, *"Artificial Intelligence: A Modern Approach"*, Prentice Hall, Fourth edition,2020.

Reference Books:

[R1] Nils J. Nilsson, *"Artificial Intelligence: A New Synthesis"*, Morgan-Kaufmann, 1998.
[R2] Judea Pearl, *"Heuristics: Intelligent Search Strategies for Computer Problem Solving"*, Addison-Wesley Publishing Company, 1984.

Other Suggested Readings:

List of Experiments:

1. Introduction to Prolog programming.
2. Python Frameworks Tutorial (with Jupyter and Colab) and it's Data Structures.
3. Searching in graph-based problem space, exploring Uninformed search Techniques.
4. Exploring Informed search Techniques (Vacuum world and Maze Problem).
5. Exploring Uninformed and Informed search Techniques (PACMAN Search Space).
6. Multiagent in a search space.
7. Introduction to Logical Agent and Knowledge representation using Prolog.
8. Reasoning Under Uncertainty using Bayesian Learning.
9. Reinforcement Learning using Q-Learning.
10. Introduction to Machine Learning and Python libraries for Data Analysis (Pandas, NumPy, Matplotlib).

Course Title: Cryptography and Digital Security

Course Code: CABM 553

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Analyze modern cryptographic primitives and evaluate their security properties.
CO-2	Design secure communication systems using authentication, key management, and network security protocols.
CO-3	Apply information hiding, privacy-preserving, and multimedia security techniques to real-world scenarios.
CO-4	Investigate emerging research problems in post-quantum cryptography, blockchain, and intelligent security systems.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1	2	1	3	2
CO2	3	3	2	2	1	3	2
CO3	2	2	2	1	2	2	3
CO4	2	3	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Foundations of Modern Cryptography (8 Hours)
Introduction to information security and security objectives including confidentiality, integrity, availability, authentication and non-repudiation. Classical cryptographic techniques and their limitations. Symmetric key cryptography including DES and AES. Modes of operation including ECB, CBC and CTR. Random number generation, cryptographic attacks and key management principles.

Unit II: Public Key Cryptography and Authentication (8 Hours)
Principles of public key cryptography. RSA cryptosystem, Diffie-Hellman key exchange and Elliptic Curve Cryptography. Cryptographic hash functions, message authentication codes, HMAC and digital signatures. Public Key Infrastructure (PKI) and certificate management.

Unit III: Network and System Security (7 Hours)
Network security fundamentals. Secure communication protocols including SSL/TLS and IPSec. Firewalls, intrusion detection systems and virtual private networks. Web and email security. Authentication mechanisms, access control models and cloud security.

Unit IV: Digital Security and Information Hiding (7 Hours)

Digital privacy and data protection principles. Steganography and steganalysis. Digital watermarking and reversible data hiding. Multimedia security, secure data sharing and digital forensics. Ethical and legal aspects of information security.

Unit V: Emerging Security Technologies (6 Hours)
Post-quantum cryptography fundamentals and quantum threats to conventional cryptographic systems. Artificial intelligence in cyber security. Adversarial attacks and defense mechanisms. Zero-trust architecture and recent research trends in cryptography and digital security.

Learning Resources:

<u>Text Books:</u>

[T1] Jonathan Katz and Yehuda Lindell, *"Introduction to Modern Cryptography"*, CRC Press, Fourth Edition, 2025.
[T2] Christof Paar, Jan Pelzl and Tim Güneysu, *"Understanding Cryptography: A Textbook for Students and Practitioners"*, Springer, Second Edition, 2024.

<u>Reference Books:</u>

[R1] Niels Ferguson, Bruce Schneier and Tadayoshi Kohno, *"Cryptography Engineering: Design Principles and Practical Applications"*, Wiley, First Edition, 2010.
[R2] Jean-Philippe Aumasson, *"Serious Cryptography: A Practical Introduction to Modern Encryption"*, No Starch Press, First Edition, 2017.
[R3] Daniel J. Bernstein, Johannes Buchmann and Erik Dahmen, *"Post-Quantum Cryptography"*, Springer, Second Edition, 2018.
[R4] Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, *"Handbook of Applied Cryptography"*, CRC Press, First Edition, 1996.
[R5] William Stallings, *"Cryptography and Network Security: Principles and Practice"*, Pearson Education, Eighth Edition, 2023.

Course Title: Computer Vision and Pattern Recognition

Course Code: CSLM 555

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Apply mathematical modeling methods for low, intermediate, and high-level image processing tasks.
CO-2	Design a new algorithm to solve are cent of the art computer vision problem.
CO-3	Perform software experiments on the computer vision problems and compare their performance with the state of the art.
CO-4	Build a complete system to solve a computer vision problem.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	1					1	
CO2	1	1	2			2	2
CO3	1	2	2	2	2	2	2
CO4	2	2	2	2	1	2	

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Introduction to computer vision (4 Hours)
Human vision, Image formation: Geometric primitives and transformations, Photometric image formation, the digital camera, how machine sees and recognizes things, Applications, Mathematical foundations.

Unit II: Pattern Recognition (8 Hours)
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).

Unit III: Convention computer vision and pattern recognition algorithms (10 Hours)
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.

Unit IV: Motion estimation, Computational photography (6 Hours)

Photometric calibration, High dynamic range imaging, Super-resolution, denoising, and blur removal, Image matting and compositing, Texture analysis and synthesis.

Unit V: Deep learning for computer vision and pattern recognition (8 Hours)
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.

Learning Resources:

<u>Text Books:</u>
[T1] Stuart Russell, Peter Norvig, *"Artificial Intelligence: A Modern Approach"*, Prentice Hall, Fourth edition,2020.

<u>Reference Books:</u>
[R1] Nils J. Nilsson, *"Artificial Intelligence: A New Synthesis"*, Morgan-Kaufmann, 1998.
[R2] Judea Pearl, *"Heuristics: Intelligent Search Strategies for Computer Problem Solving"*, Addison-Wesley Publishing Company, 1984.

M. TECH CSE (ELECTIVE) SYLLABUS

Course Title: Machine Learning

Course Code: CSBM 611

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Define the basic concepts of machine learning.
CO-2	Awareness about off-the shelf machine learning algorithms such as logistic regression, Random Forest, and Neural Networks.
CO-3	Explain overfitting, underfitting as well as real-world applications of classical machine learning techniques.
CO-4	Understanding of ensemble techniques.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3		1	1		2	1
CO2	3	3	2	1	1	3	2
CO3	1		2	1	3	3	2
CO4	3	2	2	3	1	3	1

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

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.

Learning Resources:

<u>Text Books:</u>

[T1] Shalev-Shwartz, Shai, and Shai Ben-David, *"Understanding Machine Learning: From Theory to Algorithms"*, Cambridge University Press, 2014.

<u>Reference Books:</u>

[R1] Christopher M. Bishop, *"Pattern recognition and machine learning"*, Springer, 2006.
[R2] Tom Mitchell, *"Machine Learning"*, Tata Mc Graw Hill, 1997.
[R3] Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, *"Mathematics for machine learning"*, Cambridge University Press, 2020.

Course Title: Deep Learning and Applications

Course Code: CSBM 612

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Analyze the theoretical foundations and optimization techniques of deep learning models.
CO-2	Design and implement deep neural networks for classification and prediction tasks.
CO-3	Develop CNN-based solutions for computer vision applications.
CO-4	Apply sequence models and transformer architectures for NLP and temporal data analysis.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	1	2	2			1	
CO2	1	1	2			1	2
CO3	1	2	2	2	2	2	2
CO4	2	2	2	2	1	2	

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

Syllabus:

Unit I: Foundations of Deep Learning (7 Hours)
Introduction to Artificial Intelligence, Machine Learning, and Deep Learning, Biological and Artificial Neurons, Perceptron and Multilayer Perceptron, Activation Functions, Gradient Descent and Optimization Techniques, Backpropagation Algorithm, Loss Functions, Regularization Techniques, Deep Learning Frameworks: TensorFlow and PyTorch.

Unit II: Deep Neural Networks and Optimization (7 Hours)
Deep Feedforward Neural Networks, Weight Initialization Techniques, Batch Normalization, Hyperparameter Tuning, Optimization Algorithms (SGD, Momentum, RMSProp, Adam), Vanishing and Exploding Gradient Problems, Dropout and Early Stopping, Model Evaluation Metrics.

Unit III: Convolutional Neural Networks (CNNs) (7 Hours)
Convolution Operations, Pooling Layers, CNN Architecture Design, Image Classification and Object Detection, Transfer Learning, Popular CNN Architectures:

(LeNet, AlexNet, VGGNet, ResNet, DenseNet), Applications in Medical Imaging and

Computer Vision.

Unit IV: Sequence Modeling and Natural Language Processing (7 Hours)
Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), Sequence-to-Sequence Models, Attention Mechanism, Transformer Architecture, Word Embeddings, NLP Applications: (Sentiment Analysis, Machine Translation, Text Classification)

Unit V: Advanced Deep Learning and Applications (7 Hours)
Autoencoders and Variational Autoencoders, Generative Adversarial Networks (GANs), Graph Neural Networks (GNNs), Explainable AI (XAI), Federated Deep Learning, Reinforcement Learning Fundamentals, Deep Learning for: (Healthcare, Cybersecurity, Autonomous Systems, Smart Cities, Remote Sensing), Recent Trends and Research Challenges

Learning Resources:

Text Books:

[T1] Ian Goodfellow, Yoshua Bengio, Aaron Courville, *"Deep Learning"*, MIT Press.
[T2] Sheldon M Ross, *"Neural Networks and Deep Learning"*, Elsevier, Fifth Edition.

Reference Books:

[R1] Aurélien Géron, *"Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow"*, O'Reilly Media, 2nd Edition (2019).

Other Suggested Readings:

List of Experiments:

1. Implementation of Perceptron and Multilayer Neural Networks.
2. Deep Neural Network for Classification Problems.
3. Hyperparameter Optimization using TensorFlow/PyTorch.
4. Image Classification using CNN.
5. Transfer Learning using Pre-trained Models.
6. Object Detection using YOLO/Faster R-CNN.
7. Sentiment Analysis using LSTM.
8. Text Classification using Transformer Models.
9. Autoencoder for Dimensionality Reduction.
10. GAN-based Image Generation.
11. Mini Project on Deep Learning Applications Study and implementation of AI techniques for robotics including Reinforcement Learning.

Course Title: Artificial Intelligence for Robotics

Course Code: CSBM 613

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain the fundamental concepts of Artificial Intelligence and their role in robotic systems.
CO-2	Apply search, planning, and navigation algorithms to solve robotic decision-making problems.
CO-3	Develop machine learning and deep learning models for robotic perception and autonomous operation.
CO-4	Analyze and implement reasoning and uncertainty handling techniques using logic, probabilistic models, and decision theory.
CO-5	Design reinforcement learning-based intelligent agents and evaluate ethical considerations in AI-driven robotic systems.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2						
CO2	2	3				3	2
CO3	2	2	2	2		2	2
CO4	3	2	2	2	2	2	3

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

Syllabus:

Unit I: Introduction Foundations of Artificial Intelligence and Intelligent Robotics (6 Hours)
Introduction to Artificial Intelligence, History and Evolution of AI, AI Approaches and Application Domains, Intelligent Agents and Environments, Problem Representation in AI, Knowledge Representation, Sensors and Actuators in Robotics, AI-Enabled Robotic Systems, Current Trends in AI, and Robotics.

Unit II: Search, Planning, and Robot Navigation (8 Hours)
State Space Representation, Uninformed Search Techniques, Heuristic Search Techniques, Uniform Cost Search (UCS), A* Search Algorithm, Constraint Satisfaction Problems, Automated Planning, Robot Motion Planning, Configuration Space (C-Space), Graph-Based Planning (Dijkstra and A*), Probabilistic Road Maps (PRM), Rapidly Exploring Random Trees (RRT)

Unit III: Machine Learning and Robotic Perception (8 Hours)
Introduction to Machine Learning, Linear Regression and Classification, Neural Networks and Deep Learning, Computer Vision for Robotics, Object Detection and Recognition, Scene Understanding and Semantic Segmentation, Transformers and Foundation Models, Applications of AI-Based Perception in Robotics.

Unit IV: Reasoning and Decision Making Under Uncertainty (8 Hours)
Propositional and Predicate Logic, Forward and Backward Chaining, Resolution-Based Inference, Probability Fundamentals, Bayesian Networks, Hidden Markov Models (HMMs), Particle Filtering, Fuzzy Logic, Explainable and Interpretable AI, Decision Theory and Utility Functions, Markov Decision Processes (MDPs)

Unit V: Reinforcement Learning, Autonomous Systems, and AI Ethics (6 Hours)
Reinforcement Learning Fundamentals, Model-Based and Model-Free Learning, Monte Carlo Methods, SARSA, Q-Learning, Deep Reinforcement Learning, Multi-Agent Systems, Natural Language Understanding for Robots, Human-Robot Interaction, Ethical, Social, and Safety Issues in AI, Responsible and Trustworthy AI

Learning Resources:

<u>Text Books:</u>
[T1] Stuart Russell, Peter Norvig, *"Artificial intelligence: A Modern Approach"*, Prentice Hall, Fourth edition, 2020.
[T2] Jay Alammar, *"Hands on large language models: language understanding and generation"*, Sebastopol, CA: O'Reilly, 2024.
[T3] Niku, Saeed B., *"Introduction to robotics: analysis, control, applications"*, John Wiley & Sons, 3rd Edition, 2024.

<u>Reference Books:</u>
[R1] Ian Goodfellow, Yoshua Bengio, Aaron Courville, *"Deep Learning"*, MIT Press, 2016.
[R2] Mikell.P. Groover, *"Industrial Robotics Technology: Programming and Applications"*, McGraw Hill, ISBN: 978-1259006210, 2nd Edition.

<u>Other Suggested Readings:</u>

<u>List of Experiments:</u>

1. Study and implementation of Python programming fundamentals, data structures, and AI libraries using Jupyter Notebook/Google Colab.
2. Study of Large Language Models (LLMs), their architecture, applications, advantages, limitations, and impact on engineering.
3. Study and implementation of Robot Operating System (ROS) installation, configuration, and basic ROS commands.
4. Study and implementation of Turtlesim navigation using ROS terminal commands and Python scripts.
5. Study and implementation of Single Layer Perceptron using the Delta Learning Rule.
6. Study and implementation of Multilayer Neural Network using the Backpropagation Learning Algorithm.

7. Study and implementation of robot motion planning algorithms using MATLAB Navigation Toolbox (A*, RRT, etc.).
8. Study and implementation of differential drive robot navigation using Probabilistic Roadmaps (PRM) in MATLAB Robotics Toolbox.
9. Study and implementation of DC motor speed control using Arduino and Potentiometer in Tinkercad simulation.
10. Study and implementation of AI techniques for robotics including Reinforcement Learning.

Course Title: Quantum Computing

Course Code: CSBM 614

L-T-P: 3-0-2

Credits: 4

Pre-requisites: Linear Algebra, Probability and Statistics, Design and Analysis of Algorithms

Course Outcomes:

CO-1	Explain the fundamental principles of quantum mechanics, quantum information, and quantum computation.
CO-2	Analyze quantum states, quantum gates, quantum circuits, and quantum communication protocols.
CO-3	Apply quantum algorithms to solve computational problems and evaluate their complexity advantages over classical algorithms.
CO-4	Examine quantum cryptographic protocols, quantum noise models, and quantum error correction techniques.
CO-5	Design and implement quantum programs using Qiskit and assess emerging applications of quantum computing.

Course Articulation Matrix:

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2
CO1	3	2	1	1	1	2	1
CO2	3	3	2	2	2	3	2
CO3	3	3	3	2	3	3	3
CO4	2	3	2	3	2	3	3
CO5	2	2	3	3	3	3	3

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

Syllabus:

Module-I: Mathematical Foundations and Quantum Mechanics Basics (8 Hours)
Introduction to Quantum Computing, Limitations of Classical Computing, Quantum Advantage, Complex Numbers, Vector Spaces, Linear Operators, Tensor Products, Eigenvalues and Eigenvectors, Dirac Notation, Hilbert Spaces, Quantum States, Superposition Principle, Quantum Measurement Postulates, Bloch Sphere Representation.

Module-II: Quantum Information and Quantum Circuits (8 Hours)

Qubits and Multi-Qubit Systems, Entanglement, Bell States, Density Matrix Formalism, Quantum Gates: Pauli Gates, Hadamard Gate, Phase Gates, CNOT Gate, Toffoli Gate, Fredkin Gate, Reversible Computation, Quantum Circuit Model, Universal Gate Sets, No-Cloning Theorem, Quantum Teleportation, Superdense Coding.

Module-III: Quantum Algorithms and Computational Complexity (8 Hours)
Deutsch Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Quantum Fourier Transform (QFT), Quantum Phase Estimation, Grover's Search Algorithm, Shor's Factoring Algorithm, Complexity Classes: P, NP, BPP, BQP, Quantum Computational Advantage.
Module-IV: Quantum Communication, Cryptography and Error Correction (8 Hours)
Quantum Communication Fundamentals, Quantum Channels, BB84 Protocol, E91 Protocol, Security of Quantum Key Distribution, Quantum Threats to Classical Cryptography, Introduction to Post-Quantum Cryptography, Quantum Noise Models, Decoherence, Bit Flip Code, Phase Flip Code, Shor Code, Surface Codes, Fault-Tolerant Quantum Computing.
Module-V: Quantum Programming and Emerging Applications (8 Hours)
IBM Quantum Platform, Qiskit Framework, Quantum Circuit Simulation, Execution on Quantum Hardware, Variational Quantum Eigensolver (VQE), Quantum Approximate Optimization Algorithm (QAOA), Quantum Machine Learning Fundamentals, Quantum Image Processing, Quantum Optimization, Quantum Internet, National Quantum Mission, Current Research Trends and Future Directions.

Learning Resources:

Text Books:
[T1] Michael A. Nielsen and Isaac L. Chuang, "*Quantum Computation and Quantum Information*", 10th Anniversary Edition, Cambridge University Press, 2010.
[T2] Jack D. Hidary, "*Quantum Computing: An Applied Approach*", 2nd Edition, Springer, 2021.

Reference Books:
[R1] Chris Bernhardt, "*Quantum Computing for Everyone*", MIT Press, 2019.
[R2] Maria Schuld and Francesco Petruccione, "*Machine Learning with Quantum Computers*", 2nd Edition, Springer, 2021.
[R3] John Watrous, "*The Theory of Quantum Information*", Cambridge University Press, 2018.
[R4] Ronald de Wolf, "*Quantum Computing: Lecture Notes*", QuSoft, 2023.
[R5] Hiu Yung Wong, "*Quantum Computing Architecture and Hardware for Engineers: Step by Step*", 2024.
[R6] Olivier Ezratty, "*Understanding Quantum Technologies 2024*", 2024 Edition.

Lab Experiments:
1. Introduction to IBM Quantum Experience and Qiskit.
2. Creation and Measurement of Single-Qubit States.
3. Implementation of Basic Quantum Gates.
4. Bell State Generation and Entanglement Analysis.
5. Quantum Teleportation Protocol.
6. Superdense Coding Implementation.
7. Deutsch-Jozsa Algorithm.
8. Bernstein-Vazirani Algorithm.
9. Grover's Search Algorithm.
10. Quantum Fourier Transform.

11. BB84 Quantum Key Distribution Protocol.
12. Quantum Error Correction Codes.
13. Variational Quantum Eigensolver (VQE).
14. Quantum Approximate Optimization Algorithm (QAOA).
15. Mini Project using Qiskit.

Course Title: Advanced Digital Image Processing

Course Code: CSBM 615

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain advanced image processing concepts, image transforms, and mathematical techniques used for image representation and analysis. **(L2)**
CO-2	Analyze image enhancement, restoration, and segmentation techniques for improving image quality and extracting meaningful information. **(L4)**
CO-3	Apply feature extraction, image registration, and image representation methods to solve real-world image processing problems. **(L3)**
CO-4	Design and develop advanced image processing solutions for applications such as medical imaging, remote sensing, computer vision, and intelligent image analysis systems. **(L6)**

Course Articulation Matrix:

COs / POs & PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	2	1	–	1	1	2	1
CO2	3	2	1	2	–	3	1
CO3	3	3	1	3	–	3	2
CO4	3	2	2	3	1	3	3

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

Syllabus:

Unit I: Fundamentals and Image Transform Techniques
Review of digital image fundamentals, image sampling and quantization, image models, image transforms and frequency domain analysis, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Discrete Cosine Transform (DCT), Walsh-Hadamard Transform, Karhunen-Loeve Transform (KLT), Wavelet Transform, multiresolution analysis, image representation in transform domains.

Unit II: Image Enhancement and Restoration

Spatial and frequency domain enhancement techniques, histogram processing, contrast enhancement, image smoothing and sharpening, noise models, image degradation models, inverse filtering, Wiener filtering, constrained least squares restoration, blind deconvolution, regularization techniques, and image quality assessment measures.

Unit III: Image Segmentation and Feature Extraction
Thresholding methods, edge-based segmentation, region-based segmentation, clustering techniques, watershed transformation, active contour models, feature detection, corner detection, texture analysis, shape descriptors, feature extraction using statistical, structural, and transform-based methods.

Unit IV: Image Registration and Image Representation
Image registration fundamentals, geometric transformations, feature-based registration, intensity-based registration, multimodal image registration, image matching techniques, image representation methods, boundary representation, region representation, chain codes, shape analysis, object recognition fundamentals.

Unit V: Advanced Topics and Applications
Image compression techniques, predictive and transform coding, vector quantization, image fusion, color image processing, hyperspectral image analysis, medical image processing, remote sensing image analysis, computer vision applications, deep learning for image processing, emerging trends in image analysis.

Learning Resources:

<u>**Text Books:**</u>
[T1] Rafael C. Gonzalez and Richard E. Woods, *"Digital Image Processing"*, Pearson Education, Fourth Edition.
[T2] Anil K. Jain, *"Fundamentals of Digital Image Processing"*, Pearson Education, Second Edition.

<u>**Reference Books:**</u>
[R1] R. J. Schalkoff, *"Digital Image Processing and Computer Vision"*, Wiley, First Edition.

List of Experiments:
1. Image Enhancement Using Histogram Equalization and Contrast Limited Adaptive Histogram Equalization (CLAHE)
2. Image Denoising Using Spatial Domain and Frequency Domain Filtering Techniques
3. Image Restoration Using Inverse Filtering and Wiener Filtering Techniques
4. Image Compression Using Discrete Wavelet Transform (DWT)
5. Edge Detection and Boundary Extraction Using Gradient and Laplacian Operators
6. Morphological Image Processing for Object Extraction and Shape Analysis
7. Image Segmentation Using Global, Adaptive, and Otsu Thresholding Methods
8. Region-Based Image Segmentation Using Region Growing and Watershed Algorithms
9. Clustering-Based Image Segmentation Using K-Means and Fuzzy C-Means Algorithms
10. Texture Feature Extraction and Analysis Using Gray Level Co-occurrence Matrix (GLCM)

Course Title: Motion Analytics

Course Code: CSBM 616

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Explain fundamentals of motion, video data formation, spatio-temporal representations and motion cues used in analytics
CO-2	Apply motion estimation, background modelling, optical flow and object tracking methods for dynamic scene analysis.
CO-3	Analyse trajectories, human pose, activities, and events using machine learning and deep learning models.
CO-4	Design and evaluate motion analytics pipelines for surveillance, sports, healthcare, traffic, and industrial AI applications.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1		1	2	1
CO2	3	3	2		2	3	2
CO3	3	3	3	2	2	3	3
CO4	3	3	3	2	3	3	3

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

Syllabus:

Unit I: Foundations of Motion Analytics (7 Hours)
Introduction to motion analytics; video data acquisition and representation; frames, pixels, colour spaces and temporal sampling; camera models and calibration basics; motion cues in image sequences; spatio-temporal filtering; feature points, corners, edges, and descriptors; datasets and annotation formats for motion-based AI applications.

Unit II: Motion Detection and Estimation (7 Hours)
Frame differencing, temporal differencing, and background subtraction; Gaussian mixture models and adaptive background modelling; foreground segmentation and morphological processing; image pyramids and multi-scale motion; optical flow fundamentals; Lucas-Kanade and Horn-Schunck methods; dense and sparse flow; motion vectors, block matching and performance measures.

Unit III: Object Tracking and Trajectory Analytics (8 Hours)

Single object and multiple object tracking; Kalman filter and particle filter; Mean Shift/CamShift; correlation filters; detection-based tracking; SORT/DeepSORT concepts; data association, occlusion handling and re-identification; trajectory smoothing, clustering and similarity measures; motion patterns, speed, direction, dwell time and path analytics.

Unit IV: Human Motion, Pose and Activity Analysis (7 Hours)
Human detection and pose estimation; skeleton and key-point based motion representation; gait and gesture analysis; action and activity recognition; handcrafted features such as HOG, HOF and motion history images; machine learning classifiers for motion data; introduction to CNN, 3D CNN, LSTM/GRU and transformer-based video models.

Unit V: Applications, Evaluation and Deployment (7 Hours)
Motion anomaly and event detection; crowd, traffic, sports, healthcare, security, and industrial monitoring applications; real-time video analytics pipeline using OpenCV/deep learning frameworks; edge/cloud deployment issues; latency, throughput, and computational complexity; privacy, ethics, and bias; evaluation metrics including accuracy, precision, recall, F1-score, MOTA/MOTP, ID-switches and mAP.

Learning Resources:

Text Books:
[T1] Richard Szeliski, *"Computer Vision: Algorithms and Applications",* Springer Nature, Second Edition, 2022.
[T2] David A. Forsyth and Jean Ponce, *"Computer Vision: A Modern Approach"*, Pearson Education / Prentice Hall, Second Edition, 2012.

Reference Books:
[R1] Richard Hartley and Andrew Zisserman, "*Multiple View Geometry in Computer Vision*", Cambridge University Press, Second Edition, 2004.

Course Title: Data Handling and Visualization

Course Code: CSBM 617

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	To understand how large data sets are handled to extract meaningful information.
CO-2	To learn the concepts of data visualization in a hands-on learning environment.
CO-3	To learn the visualization of large data sets using R and principles of query visualization.
CO-4	To gain hands-on experience by visualizing data with real-world scenarios through projects and case studies.

Course Articulation Matrix:

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2
CO1	3	2	1	1	1	2	1
CO2	3	3	2	2	2	3	2
CO3	3	3	3	2	3	3	3
CO4	2	3	2	3	2	3	3
CO5	2	2	3	3	3	3	3

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

Syllabus:

Unit I: Introduction to Data Handling (10 Hours)
Introduction to Data, Types of Data, Life Cycle of Data, Managing Data, Data Analysis, High Dimensionality Data Handling, Challenges in Data Handling, Overview of Big Data, Big Data Stack, Virtualization and Big Data, Handling Variety of Data, Multi-Model Databases.

Unit II: Data Visualization (8 Hours)
Introduction to Data Visualization, Pipeline of Data Visualization, Overview of Data Visualization Specifications, Data Visualization Languages, Visualization Tools, Efficient Approaches of Data Visualization, Integrating Visualization Systems with DBMSs, Exploring GUI-based Tools, Data Preparation for Data Visualization, Data Visualization for database-related applications.

Unit III: Visualizing Data with R (8 Hours)
Introduction to R, Data Types and Objects in R, Loading and Handling Data in R, Exploring Data in R, Using R with Databases and Business Intelligence Systems, Visualization Using R.

Unit IV: Query Visualization (08 Hours)
Introduction to Query Visualization and What it is for, What Query Visualization is Not, Challenges of Query Visualization, Principles of Query Visualization and Design trade-offs, QueryVis and Relational Diagrams.

Unit V: Handling and Visualizing Data: Real World Scenarios (06 Hours)
Challenges and Open Problems of Handling Variety of Data, Case Study on Handling and Visualizing Data with Real-world Scenarios such as Healthcare, Business, E-Commerce etc.

Learning Resources:

<u>Text Books:</u>
[T1] Steve Wexler, Jeffrey Shaffer, and Andy Cotgreave, *"The Big Book of Dashboards: Visualizing your Data using Real-World Business Scenarios"*, Wiley, 2017.
[T2] Seema Acharya, *"Data Analytics using R"*, McGraw Hill Education, 2018.
[T3] Saroj Dahiya Ratnoo and Himmat Singh Ratnoo, *"Essentials of R for Data Analytics"*, Wiley, 2021.

<u>Reference Books:</u>
[R1] G. Sudha Sadasivam, R. Thirumahal, *"Big Data Analytics"*, Oxford Higher Education, 2020.
[R2] M. Thangaraj, S.Suguna, G. Sudha, *"Big Data Analytics Concepts, Techniques, Tools and Technologies"*, PHI Learning Private Limited, 2022.
[R3] Research Papers from ACM, VLDB, SIGMOD, ACM Computing Surveys stc.

<u>Other Suggested Readings:</u>

<u>List of Experiments:</u>

Course Title: Optimization Techniques

Course Code: CSLM 618

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	To understand the fundament of Linear Programming and Dynamic Programming.
CO-2	Enumerate fundamentals of Integer programming technique and apply different techniques to solve various optimization problems arising from engineering areas.
CO-3	Identify appropriate optimization method to solve complex problems involved in various industries.
CO-4	To understand the graphical, simplex, and analytical methods for making effective decision.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2					1	
CO2	1	1	2			1	2
CO3	1	2	1	2	2	2	2
CO4	2	2	2	2	1	2	

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

Syllabus:

Unit 1:
Preliminaries: Proofs, Vector Spaces and Matrices, Linear Transformations, Eigenvalues and Eigenvectors, Orthogonal Projections, Quadratic Forms, Matrix Norms, Concepts from Geometry, Elements of Calculus.

Unit 2:
Unconstrained Optimization: Basics of Set Constrained and Unconstrained Optimization, One Dimensional Search Methods, Golden Section Search, Fibonacci Search, Newton's Method, Secant Method, Solving Ax = b.

Unit 3:
Linear Programming: Introduction to Linear Programming, Simplex Method, Duality.

Unit 4:

Nonlinear Constrained Optimization: Problems with Equality Constraints, Problems with Inequality Constraints, Karush Kuhn Tucker Condition, Convex Optimization Problems.

Unit 5:

Algorithms for Constrained Optimization: Projections, Project gradient methods, Penalty methods.

Learning Resources:

Text Books:

[T1] Edwin K.P. Chong, Stanislaw H. Zak, *"An Introduction to Optimization"*, Wiley, Fourth Edition.

Reference Books:

[R1] Stephen Boyd, *"Convex Optimization"*, Lieven Vandenberghe, Third Edition.
[R2] Paulo Cortez, *"Modern Optimization with R (Use R)"*, Springer, 2014.

Course Title: Game Theory

Course Code: CSLM 619

L-T-P: 3-1-0

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Understanding of the basic concept of game theory.
CO-2	Understanding of Nash Equilibrium.
CO-3	Ability to design the Prisoner's Dilemma.
CO-4	Ability to design Pricing and Resource Allocation.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2					2	
CO2	3	1	2			1	2
CO3	2	1	2	2	2	2	2
CO4	2	2	1	2	1	2	

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

Syllabus:

Unit 1
Introduction: What is game theory, The theory of rational choice, interacting decision makers

Unit 2
Nash Equilibrium: Theory Strategic games; the Prisoner's Dilemma, Bach or Stravinsky, Brass Paradox, Matching Pennies, the stag Hunt, Nash Equilibrium, Best response functions, Dominated actions, Equilibrium in single population.
Mixed Strategy Equilibrium Introduction, Mixed strategy Nash equilibrium, the formation of players' beliefs, finding all mixed strategy Nash equilibria, games in which each player has a continuum of actions.

Unit 3
Extensive Games with Perfect Information Introduction, Strategies and outcomes, Nash equilibrium, Subgame perfect equilibrium, Finding subgame perfect equilibria of finite horizon games, Stackelberg's model of duopoly.
Repeated Games: The Prisoner's Dilemma, General Result

Unit 4
Bargaining as an extensive game, Illustration: trade in a market, Nash's axiomatic model, Relation between strategic and axiomatic models

Unit 5
Incentives and Pricing in Communications Networks: Large Networks, Pricing and Resource Allocation, Alternative Pricing, and Incentive Approaches.

Learning Resources:

<u>**Text Books:**</u>
[T1] Noam Nisan, Tim Roughgarden, Eva Tardos, and Vijay V. Vazirani., *"Algorithmic Game Theory",* Cambridge University Press, 2007.
[T2] Osborne, M. J., *"An introduction to game theory"*, Oxford Univ. Press.

<u>**Reference Books:**</u>
[R1] Robert Gibbons, "*Game Theory for Applied Economists"*, Princeton University Press, 1992.

List of Tutorials:
1. Study and implementation of Forward and Inverse Kinematics of a Robotic Manipulator.
2. Study and simulation of Denavit-Hartenberg (D-H) Parameter-based Robot Modeling.
3. Study and implementation of Robot Path Planning using Dijkstra's and An Algorithms. *
4. Study and implementation of Autonomous Navigation using Rapidly exploring Random Trees (RRT).
5. Study and simulation of Obstacle Detection and Avoidance Techniques for Mobile Robots.
6. Study and implementation of Simultaneous Localization and Mapping (SLAM) using Robot Simulation Tools.
7. Study and implementation of Visual Odometry and Pose Estimation using Camera Data.
8. Study and implementation of Object Detection and Tracking for Robotic Vision Applications.
9. Study and implementation of Fuzzy Logic and Neural Network based Intelligent Robot Control Systems.
10. Study and simulation of Autonomous Robot Navigation and Multi-Robot Coordination using ROS/Gazebo.

Course Title: Natural Language Processing

Course Code: CSLM 620

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Understand the fundamental concepts of natural language processing, including models, ambiguity, processing paradigms, and phases of NLP along with text representation in computers.
CO-2	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.
CO-3	Demonstrate the ability to perform Part-of-Speech tagging, statistical and probabilistic parsing, and handle challenges like unknown words and multi-word expressions.
CO-4	Evaluate semantic analysis techniques, Word Sense Disambiguation methods, and NLP applications such as sentiment analysis, summarization, and machine translation.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2			2	3	2
CO2	3	3	2	2	3	3	2
CO3	3	3	2	2	3	3	3
CO4	3	3	2	3	3	3	3

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

Syllabus:

Unit 1: Introduction to Natural Language Processing
Introduction Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. Text representation in computers.

Unit 2: Linguistic Resources and Statistical Foundations
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.

Unit 3: POS Tagging and Parsing Techniques

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.

Unit 4: Semantics and Text Analysis
Semantics Meaning representation, semantic analysis, lexical semantics, WordNet, Word Sense Disambiguation, Selectional restriction, machine learning approaches, dictionary-based approaches. Text Classification Sentiment Analysis.

Unit 5: NLP Applications
Applications of NLP Spell checking, text summarization, machine translation, chatbots, question answering, text generation, speech-based systems, named entity recognition, and topic modeling.

Learning Resources:

Text Books:

[T1] Daniel Jurafsky and James H Martin, *"Speech and Language Processing"*, Pearson Education, 2009.

Reference Books:

[R1] Siddiqui T., Tiwary U. S., *"Natural language processing and Information retrieval"*, OUP, 2008.

[R2] James A, *"Natural language Understanding"*, Pearson Education, 1994.

[R3] Bharati A., Sangal R., Chaitanya V., *"Natural language processing: a Paninian perspective"*, PHI, 2000.

Course Title: Reinforcement Learning and Applications

Course Code: CSLM 621

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Explain the fundamental concepts, mathematical foundations, and learning paradigms of reinforcement learning. **(L2)**
CO-2	Analyze value-based, policy-based, and model-based reinforcement learning algorithms for solving sequential decision-making problems. **(L4)**
CO-3	Apply classical and deep reinforcement learning techniques to develop intelligent agents for complex environments. **(L3)**
CO-4	Design and implement reinforcement learning solutions for real-world applications while evaluating their performance and scalability. **(L6)**

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1	2	1	3	2
CO2	3	3	2	2	1	3	2
CO3	2	2	2	1	2	2	3
CO4	2	3	3	3	2	2	3

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

Syllabus:

Unit I: Fundamentals of Reinforcement Learning
Introduction to machine learning paradigms, supervised, unsupervised and reinforcement learning, reinforcement learning framework, agents and environments, rewards and returns, exploration and exploitation, Markov Decision Processes (MDP), Bellman equations, finite and infinite horizon problems, dynamic programming, policy evaluation and policy improvement.

Unit II: Model-Free Reinforcement Learning
Monte Carlo methods, Temporal Difference (TD) learning, SARSA algorithm, Q-Learning, Expected SARSA, eligibility traces, TD(λ), on-policy and off-policy learning, convergence properties, function approximation techniques, practical implementation issues.

Unit III: Deep Reinforcement Learning

Introduction to deep learning for RL, neural network function approximation, Deep Q-Networks (DQN), experience replay, target networks, Double DQN, Dueling DQN, Deep Deterministic Policy Gradient (DDPG), Trust Region Policy Optimization (TRPO), Proximal Policy Optimization (PPO), actor-critic methods.

Unit IV: Advanced Reinforcement Learning Techniques

Policy gradient methods, stochastic and deterministic policies, model-based reinforcement learning, multi-agent reinforcement learning, hierarchical reinforcement learning, inverse reinforcement learning, imitation learning, transfer learning in RL, safe reinforcement learning, exploration strategies.

Unit V: Reinforcement Learning Applications

Reinforcement learning in robotics, autonomous vehicles, game playing systems, recommender systems, finance and algorithmic trading, resource allocation, wireless networks, smart grids, healthcare applications, industrial automation, reinforcement learning for large-scale decision-making systems, ethical considerations and future trends.

Learning Resources:

<u>Text Books:</u>

[T1] Richard S. Sutton and Andrew G. Barto, *"Reinforcement Learning: An Introduction"*, MIT Press, Second Edition.

[T2] Maxim Lapan, *"Deep Reinforcement Learning Hands-On"*, Packt Publishing, Third Edition.

<u>Reference Books:</u>

[R1] Csaba Szepesvári, *"Algorithms for Reinforcement Learning"*, Morgan & Claypool Publishers, First Edition.

Course Title: Information Retrieval

Course Code: CSLM 622

L-T-P: 3-0-0

Credits: 3

Pre-requisites: Database management system, Data structures

Course Outcomes:

CO-1	Analyze and implement indexing structures, query processing techniques, and efficient retrieval mechanisms.
CO-2	Apply retrieval models and evaluate the effectiveness of information retrieval systems using standard performance measures.
CO-3	Design document classification and clustering solutions using machine learning and statistical approaches.
CO-4	Develop and analyze web-scale retrieval systems using crawling, indexing, ranking, and link analysis techniques.

Course Articulation Matrix:

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2
CO-1	3	2	1	3	1	3	1
CO-2	3	3	1	3	1	3	1
CO-3	3	3	1	3	1	3	2
CO-4	2	3	2	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module-1

Indexing and Retrieval Foundations

Boolean Retrieval Model, Inverted Index Construction, Processing Boolean Queries, Extended Boolean Model, Term Vocabulary and Postings Lists, Positional Indexes, Phrase Queries, Dictionaries and Tolerant Retrieval, Wildcard Queries, Spelling Correction, Blocked Sort-Based Indexing, SPIMI, Distributed Indexing and Dynamic Indexing.

Module-2

Retrieval Models and Evaluation

Index Compression, Dictionary Compression, Postings Compression, Vector Space Model, Term Weighting, TF-IDF, Efficient Scoring and Ranking, Query Processing, Retrieval System Architecture, Precision, Recall, F-Measure, Mean Average Precision, NDCG, Relevance Assessment.

Module-3

Advanced Retrieval Models

Relevance Feedback, Pseudo-Relevance Feedback, Query Expansion, XML Retrieval, XML Retrieval Evaluation, Probabilistic Information Retrieval, Probability Ranking Principle, Binary Independence Model, Language Models for Information Retrieval, Query Likelihood Model.

Module-4

Text Mining and Web Retrieval

Text Classification, Naive Bayes Classification, Rocchio Classification, k-Nearest Neighbour Classification, Document Clustering, k-Means Clustering, Hierarchical Clustering, Latent Semantic Indexing, Singular Value Decomposition, Web Search Architecture, Web Crawling, Distributed Indexing, PageRank, HITS Algorithm, Neural Information Retrieval and Semantic Search.

<u>Learning Resources:</u>

<u>Text Books:</u>

[T1] Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze, "*Introduction to Information Retrieval*", Cambridge University Press, 2008.

[T2] David A. Grossman and Ophir Frieder, "*Information Retrieval: Algorithms and Heuristics*", Springer, 2nd Edition, 2004.

<u>Reference Books:</u>

[R1] Gerald J. Kowalski and Mark T. Maybury, "*Information Storage and Retrieval Systems: Theory and Implementation*", Springer, 2nd Edition, 2005.

[R2] Ricardo Baeza-Yates and Berthier Ribeiro-Neto, "*Modern Information Retrieval*", Addison-Wesley, 2nd Edition, 2011.

Course Title: Fuzzy Logic and Applications

Course Code: CSLM 623

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Provides the basic concepts in fuzzy sets and fuzzy relations.
CO-2	Teaches techniques for converting crisp data to fuzzy data and vice versa.
CO-3	Enhancement of the ability to solve problems based on fuzzy arithmetic.
CO-4	Training for handling fuzzy data using fuzzy measures.

Course Articulation Matrix:

COs	**POs & PSOs**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	2	1		2		2	
CO2	3	1		2		3	1
CO3	3	2		3		3	1
CO4	2	2		3	2	2	1

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

Syllabus:

Unit I: Introduction (8 Hours)
Introduction: crisp sets, an overview; the notion of fuzzy sets; basic concepts of fuzzy sets; membership functions; methods of generating membership functions; defuzzification methods; operations on fuzzy sets; fuzzy complement, fuzzy union, fuzzy intersection; combinations of operations; general aggregation operations.

Unit II: Link Analysis and Node Importance (9 Hours)
Fuzzy numbers, arithmetic operations on intervals, arithmetic operations on fuzzy numbers, fuzzy equations, crisp and fuzzy relations, binary relations, binary relations on a single set, equivalence and similarity relations, compatibility, or tolerance relations.

Unit III: Community Detection (8 Hours)
Fuzzy measures, belief and plausibility measures, probability measures, possibility and necessity measures, possibility distribution, relationship among classes of fuzzy measures.

Unit IV: Fuzzy logic and applications (9 Hours)
Fuzzy logic and applications: classical logic, an overview, fuzzy logic, approximate reasoning,

other forms of implication operations, other forms of the composition operations, fuzzy decision making, fuzzy logic in database and information systems, fuzzy pattern recognition, fuzzy control systems.

Learning Resources:

Text Books:

[T1] George J. Klir and Tina A. Folger, "*Fuzzy Sets: Uncertainty and Information*", Prentice Hall of India, New Delhi, 1998.

[T2] Hans-Jürgen Zimmermann, "*Fuzzy Set Theory and Its Applications*", Kluwer Academic Publishers, Boston, MA, 2001.

Reference Books:

[R1] Timothy J. Ross, "*Fuzzy Logic with Engineering Applications*", McGraw-Hill Inc., New York, 1997.

Course Title: Social Network Analysis

Course Code: CSLM 624

L - T - P: 3 - 0 - 0

Credits: 3

Semester:

Pre-requisites: Data Structures, Graph Theory, Probability and Statistics

Course Outcomes:

CO-1	Understand the fundamentals of Social Network Analysis, its applications across domains, data collection methods via APIs, and graph visualization tools for network representation. [Bloom's L1, L2]
CO-2	Analyze social network structures using node centrality measures (degree, closeness, betweenness, Katz), network growth models, and properties of real-world networks. [Bloom's L4, L5]
CO-3	Apply community detection and link analysis techniques including PageRank, Hub-Authority, triadic closure, and overlapping/disjoint community detection algorithms to social graphs. [Bloom's L3, L4]
CO-4	Evaluate link prediction methods, cascade behavior and epidemic spread models (SEIR, SIR, SIS), and implement privacy-preserving techniques including K-anonymity, L-Divergence, and T-Closeness for secure social network applications. [Bloom's L5, L6]

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

COs	**POs-PSOs**						
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PSO-1**	**PSO-2**
CO1	3	2	2		1	3	2
CO2	3	2	2	2	1	3	2
CO3	3	3	2	2	2	3	3
CO4	3	3	2	2	2	3	3

1 - Slightly; 2 – Moderately 3 - Substantially

Syllabus:

Module-I

Introduction to Social Network Analysis (SNA), applications of SNA, social media and online networks, data collection from social media and APIs, challenges in SNA, graph representation of networks, graph visualization tools, introduction to NetworkX, Gephi, and Cytoscape.

Module-II

Networks and graphs, types of networks, network properties, degree distribution, clustering coefficient, centrality measures (degree, closeness, betweenness, eigenvector, and Katz centrality), k-cliques and communities. Real-world network properties, random graph model, Watts–Strogatz small-world model, Barabási–Albert scale-free model, temporal and multilayer networks.

Module-III

Link analysis and applications, signed networks, strong and weak ties, triadic closure, PageRank, Personalized PageRank, HITS algorithm. Community detection, graph partitioning, modularity, spectral clustering, Girvan–Newman algorithm, Louvain method, disjoint and overlapping communities, evaluation of communities, identification of influential nodes.

Module-IV

Link prediction and recommendation systems, similarity-based and probabilistic approaches. Information diffusion, Independent Cascade and Linear Threshold models, random walks, rumor propagation, epidemic models (SI, SIS, SIR, and SEIR). Privacy and security in social networks, trust and reputation systems, privacy-preserving techniques, k-anonymity, l-diversity, and t-closeness.

Learning Resources:

Text Books:

[T1] M. E. J. Newman, "*Networks: An Introduction*", Oxford University Press, 2010.
[T2] Albert-László Barabási, "*Network Science*", Cambridge University Press, 2016.

Reference Books:

[R1] S. Wasserman and K. Faust, "*Social Network Analysis: Methods and Applications*", Cambridge University Press, 1994.
[R2] Matthew Russell, "*Mining the Social Web*", O'Reilly Media, 2014.
[R3] M. Newman, A. Barabási, and D. Watts, "*The Structure and Dynamics of Networks*", Princeton University Press, 2006
[R4] D. Easley and J. Kleinberg, "*Networks, Crowds and Markets*", Cambridge University Press, 2010.

Course Title: Soft Computing

Course Code: CSLM 625

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Define the basic concepts of soft computing.
CO-2	Explain applications & operations of Fuzzy Logic in real life Problems.
CO-3	Apply different FIS models to solve optimization problems. Analyze and examine Evolutionary and swarm algorithms in solving real world multi-Objective optimization problems.
CO-4	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.

Course Articulation Matrix:

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	3	2	2			2	2
CO2	2	2	2		2	2	2
CO3	3	2	2		2	2	2
CO4	3	2	2	2	2	2	2

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

Syllabus:

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.

Unit IV: Hybrid Intelligent System: Neuro-Fuzzy (8 Hours)
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

Unit V: Optimization Techniques (6 Hours)
Introduction to Optimization, Genetic algorithms, Procedure and working of GA, Particle swarm optimization, MATLAB programming.

Learning Resources:

<u>Text Books:</u>

[T1] Simon Haykin, *"A comprehensive foundation. Neural Networks"*, Pearson, Second Edition, 2001.

<u>Reference Books:</u>

[R1] Timothy J. Ross, *"Fuzzy logic with engineering applications"*, John Wiley & Sons, Third Edition, 2009.
[R2] Melanie Mitchell, *"An Introduction to Genetic Algorithms"*, Prentice-Hall, 1998.
[R3] D. E. Goldberg, *"Genetic Algorithms in Search, Optimization, and Machine Learning"*, Addison-Wesley, 1989.
[R4] S. V. Kartalopoulos, *"Understanding Neural Networks and Fuzzy Logic: Basic Concepts and Applications"*, IEEE Press, 2014.
[R5] S. Rajasekaran & G. A. Vijayalakshmi Pai, *"Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications"*, PHI, 2003.
[R6] S. N. Sivanandam & S. N. Deepa, *"Principles of Soft Computing"*, Wiley - India, Second Edition, 2007.

Course Title: Cloud Computing

Course Code: CSBM 631

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Describe the fundamental concepts, architectures, and service models of cloud computing.
CO-2	Analyze virtualization technologies and resource management techniques used in cloud environments.
CO-3	Apply cloud platforms and services to deploy, manage, and scale distributed applications.
CO-4	Assess security, privacy, and reliability challenges in cloud computing systems.
CO-5	Evaluate emerging cloud technologies, research trends, and cloud–based solutions for complex computing problems.

Course Articulation Matrix:

COs	**POs & PSOs**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	3	1		1	2	1	1
CO2	3	2		2	1	3	2
CO3	3	2		2	1	2	2
CO4	3	2	1	2	1	3	2
CO5	2	3	1	2	1	2	3

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

Syllabus:

Unit I: Introduction to Cloud Computing (8 Hours)
Evolution of Distributed Computing, Grid Computing, Utility Computing, Cloud Computing Concepts, Characteristics, Cloud Reference Architecture, Service Models (IaaS, PaaS, SaaS), Deployment Models, Cloud Ecosystem and Applications.

Unit II: Virtualization and Resource Management (8 Hours)
Hypervisors, Server, Storage and Network Virtualization, Containerization, Docker, Resource Provisioning, Scheduling, Load Balancing, Data Center Architecture.

Unit III: Cloud Platforms and Services (8 Hours)
AWS, Microsoft Azure, Google Cloud Platform, Storage Services, Compute Services, Database Services, SOA, Microservices, Cloud APIs.

Unit IV: Cloud Security and Reliability (7 Hours)
IAM, Authentication, Authorization, Data Security, Encryption, Compliance, Disaster Recovery, Fault Tolerance and Reliability.

Unit V: Advanced Cloud Computing (5 Hours)
Edge Computing, Fog Computing, Serverless Computing, Kubernetes, Multi-cloud Architectures, AI/ML in Cloud, Research Challenges and Future Trends.

Learning Resources:

Text Books:

[T1] Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra, *"Distributed and Cloud Computing: From Parallel Processing to the Internet of Things"*, Elsevier, First Edition, 2012

[T2] Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, "*Mastering Cloud Computing: Foundations and Applications Programming*", McGraw Hill Education, 1st Edition.

Reference Books:

[R1] Thomas Erl, Ricardo Puttini, Zaigham Mahmood, *"Cloud Computing: Concepts, Technology & Architecture"*, Pearson Education, 1st Edition 2013.

[R2] Barrie Sosinsky, *"Cloud Computing Bible"*, Wiley Publishing, Second Edition, 2011.

[R3] Dan C. Marinescu, *"Cloud Computing: Theory and Practice"*, Morgan Kaufmann, Second Edition, 2017.

Other Suggested Readings:

List of Experiments:

1. Virtual Machine Configuration using VirtualBox/VMware: To install, configure, and manage virtual machines using virtualization platforms such as VirtualBox or VMware and understand resource allocation in virtualized environments.
2. Cloud Instance Creation in AWS/Azure/GCP: To create, configure, and manage virtual machine instances on public cloud platforms and understand cloud resource provisioning.
3. Web Application Deployment on Cloud Platforms: To deploy and host a web application on a cloud platform and analyze the deployment process and service configurations.
4. Cloud Storage and Database Services: To explore cloud-based storage and database services and implement data storage, retrieval, and management in a cloud environment.
5. Docker Container Deployment: To create, deploy, and manage containerized applications using Docker and understand containerization concepts.
6. Kubernetes Orchestration: To deploy, manage, and scale containerized applications using Kubernetes and understand container orchestration mechanisms.
7. Identity and Access Management (IAM) Configuration: To configure user identities, roles, permissions, and access policies in cloud environments for secure resource management.
8. Cloud Monitoring and Performance Analysis: To monitor cloud resources and applications using cloud monitoring tools and evaluate system performance and resource utilization.
9. Load Balancing and Auto-Scaling Implementation: To implement load balancing and auto-scaling mechanisms for improving availability, scalability, and performance of cloud applications.

Course Title: Internet of Things

Course Code: CSBM 632

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain the architecture, components, and enabling technologies of IoT systems.
CO-2	Design IoT networks using suitable communication technologies and protocols.
CO-3	Develop machine learning and deep learning models for robotic perception and autonomous operation.
CO-4	Analyze security, privacy, and trust challenges in IoT environments and propose appropriate solutions.
CO-5	Design and implement intelligent IoT applications for industrial and societal needs.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	1	1	1	2	2	2	2
CO2	2	1	2	2	2	2	3
CO3	3	3	2	1	2	3	2
CO4	3	2	3	2	2	3	3

Syllabus:

Unit I: Introduction to Internet of Things (7 Hours)
Fundamentals of IoT, Evolution and Characteristics of IoT, IoT Architecture and Design Principles, IoT Reference Models, Physical and Logical Design of IoT Systems, Sensors, Actuators, and Embedded Systems, IoT Ecosystem and Enabling Technologies, Applications of IoT.

Unit II: IoT Devices, Connectivity and Communication Protocols (7 Hours)
IoT Hardware Platforms, Arduino, Raspberry Pi, ESP32, Wireless Communication Technologies (Wi-Fi, Bluetooth Low Energy (BLE), ZigBee, LoRaWAN, NB-IoT), IPv6 for IoT, 6LoWPAN, MQTT Protocol, CoAP Protocol, AMQP and DDS, Edge, and Fog Computing.

Unit III: IoT Data Management and Cloud Integration (7 Hours)
IoT Data Acquisition and Processing, IoT Middleware, Cloud Computing for IoT, Data Storage and Management, Stream Processing, Big Data Analytics in IoT, IoT Platforms, AWS IoT, Azure IoT Hub, Google Cloud IoT, Digital Twin Concepts.

Unit IV: IoT Security, Privacy and Trust Management (7 Hours)
Security Challenges in IoT, Authentication and Authorization, Access Control Mechanisms, Secure Communication Protocols, Cryptography for IoT, Blockchain-enabled IoT, Privacy

Preservation Techniques, Trust Management in IoT, Security Standards and Best Practices

Unit V: Advanced IoT Applications and Emerging Trends (7 Hours)
Industrial IoT (IIoT), Smart Cities and Smart Governance, Smart Healthcare and Wearable Systems, Smart Agriculture, Intelligent Transportation Systems, IoT and Artificial Intelligence (AIoT), Edge AI for IoT, Digital Twins and Cyber-Physical Systems, Industry 4.0 and Smart Manufacturing, Recent Research Trends and Challenges.

Learning Resources:

Text Books:

[T1] Arshdeep Bahga and Vijay Madisetti, *"Internet of Things: A Hands-On Approach"*, Universities Press, 2025.
[T2] Rajkumar Buyya and Amir Vahid Dastjerdi, *"Internet of Things: Principles and Paradigms"*, Morgan Kaufmann (Elsevier). 2016.

Reference Books:

[R1] Maciej Kranz, *"Building the Internet of Things"*, Wiley, 2016.
[R2] Dieter Uckelmann, Mark Harrison, Florian Michahelles, *"Architecting the Internet of Things"*, Springer Berlin Heidelberg, 2016.
[R3] Adrian McEwen and Hakim Cassimally, *"Designing the Internet of Things"*, Wiley, 2016.

Other Suggested Readings:

List of Experiments:

1. Sensor interfacing using Arduino/ESP32.
2. IoT device programming and data acquisition.
3. MQTT-based communication between IoT devices.
4. Wireless sensor data transmission using Wi-Fi/BLE.
5. Cloud integration using AWS IoT or Azure IoT.
6. IoT dashboard development for real-time monitoring.
7. Edge computing implementation for IoT applications.
8. Secure IoT communication using encryption techniques.
9. Smart home automation system development.
10. IoT-based predictive monitoring application.
11. Mini Project on Industrial or Smart City IoT Solutions.

Course Title: Big Data Analytics

Course Code: CSBM 633

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Analyze the characteristics, challenges, and architectural components of Big Data systems, and evaluate various Big Data storage and processing frameworks.
CO-2	Design and implement distributed data processing solutions using Big Data technologies such as Hadoop, MapReduce, HDFS, Spark, and NoSQL databases.
CO-3	Apply advanced data preprocessing, mining, and machine learning techniques to extract actionable knowledge from large-scale structured and unstructured datasets.
CO-4	Develop scalable analytics models for real-time and batch data processing and assess their performance in diverse application domains.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	2	1		2	3
CO2	3	2	1	3		2	2
CO3	3	2	3	2	2	2	3
CO4	2	3	3	2	2	3	3

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

Syllabus:

Unit 1 (5 Hours)
Fundamentals of Business Analytics-Business Intelligence (BI), Business Intelligence vs. Business Analytics, BI Framework, BI Roles & Responsibilities, BI DW Best Practices, Popular BI Tools, BI Applications.

Unit 2 (8 Hours)
Big Data Analytics in Memory Analytics, In Database Processing, Symmetric Multiprocessor System (SMP), Massively Parallel Processing, Shared Nothing Architecture, Parallel and Distributed Systems, CAP Theorem.

Unit 3 (8 Hours)
Typical enterprise application architecture Visualizing Relationship in Data, Probability, Estimation, Outliers and Normal Distribution, Inference, Regression, Exploratory Data Analysis (EDA), Big Data, Scaling Problems, HDFS, Design Patterns, Cluster.

Unit 4 (8 Hours)
Data analytic life cycle, Advance analytic theory, and method: "Clustering", Advance analytic theory, and method: "Association,", Advance analytic theory and method: "Classification", Advance analytic theory, and method: “Regression”.

Unit 5 (7 Hours)
Big Data Analytics Tool Hadoop, MongoDB, Cassandra, MapReduce, Hive, Pig, Oozie.

Learning Resources:

Text Books:
[T1] “*Data Science and Big Data Analytics”*, Wiley, 1st Edition.
[T2] R.N. Prasad, Seema Acharya, *“Fundamentals of Business Analytics”*, Wiley, 2nd Edition.
[T3] Michael Minelli, Michele Chambers, Ambiga Dhiraj, *“Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses”*, Wiley, 1st Edition.

Reference Books:
[R1] Jeffery Stanton, *“An Introduction to Data Science”*, SAGE, 1st Edition.
[R2] Seema Acharya, Subhashini Chellapan, *“Big Data and Analytics”*, Wiley, 2nd Edition.

Course Title: Information Security and Privacy

Course Code: CSLM 634

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	To understand the basic principles of Information Security & Privacy management.
CO-2	To understand the basic concepts of the technical components involved in implementing security & privacy.
CO-3	To understand that ensuring information security & privacy in a modern organization is a problem for the management to solve and not one that the technology alone can address.
CO-4	To analyze the important economic and commercial consequences of devising security and privacy solutions in an enterprise or the lack thereof.

Course Articulation Matrix:

COs	**POs & PSOs**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	2						
CO2	3	2				2	3
CO3	2	3	2		2	2	2
CO4	2	2	2	2	2	3	2

1 - Slightly; 2 - Moderately; 3 Substantially

Syllabus:

Unit I: Introduction (7 Hours)
Introduction to Information Security and Privacy: Review of the essential terminologies, basic concepts of security and privacy. Relation or lack thereof between the Information Security, Network Security, Systems Security, and the Cyber Security. Key principles of Information Security in terms of Security mechanisms, security attributes and the security attacks. Role of National Security Systems (CNSS) and CERTIN. The McCumber Cube for Security. Introduction to the Security Systems Development Life Cycle and the difference between the Software Security and the Security Software. Classical Security Models.

Unit II: Security Threats and Security Attacks (8 Hours) Taxonomy of Security attacks. Illustrations of typical attacks. Cyber security threats. The basic terminologies viz. threats, defects, vulnerabilities, exploits, attacks, bugs. The importance of Data privacy; Privacy rules; Data Protection – Organization Roles. Approaches to protect sensitive data. Personally Identifiable Information and Sensitive Data. Data Privacy and Protection Responsibilities. Consequences Of Privacy Unawareness. Overview Of Global Data Privacy Laws. The DSCI Privacy Framework for global privacy best practices and frameworks.

Unit III: Security Technologies -I (7 Hours)
Security Mechanisms: The Symmetric and Asymmetric Key Cryptography, Ciphers: Cryptographic Algorithms and the Cryptosystems, Mechanisms for Data Integrity and Entity Authentication, Access Control mechanisms. Cryptographic Tools: The Public-Key-Infrastructure (PKI), Digital Signatures, Digital Certificates, Hybrid Cryptographic Systems, Steganography. The Public Key Cryptography (PKC) limitations and looking beyond the PKC.

Unit IV: Security Technologies- II (7 Hours)
Protocols for Secure Communications: S-HTTP, TLS for Secure Internet Communication, S/MIME, PEM, PGP for Secure Email, the SET, TLS, and S-HTTP for Securing Web Transactions, WEP and WPA for Secure Wireless Communications, Securing TCP/IP with IPSec PGP. Firewalls: Processing Modes, Categorized by Generations, by Structure, Architectures, Selecting the right firewall, Configuring and Managing Firewalls. Remote Access, the concept of Virtual Private Networks.

Unit V: Security Technologies -III (7 Hours)
Intrusion Detection and Prevention Systems: Why use IDPSs, Types, IDPSs Detection Methods, IDPS Response Behaviour, IDPS Approaches. Strengths and Limitations. Deployment and Implementation of IDPSs. Measuring the effectiveness of IDPSs. Honeypots, Honeynets and Padded Cell Systems. Network Reconnaissance: Network Scanning and Analysis. Legal and Ethical Issues in Information Security and Privacy. Introduction to Cyber Laws. Introduction to Security policies and Security Acts.

Learning Resources:

Text Books:
[T1] Michael E. Whitman, Herbert J. Mattord, *"Principles of Information Security"*, Course Technology Press, 4th edition, 2011.
[T2] Dieter Gollmann, *"Computer Security"*, Wiley, 3rd Edition, 2014

Reference Books:
[R1] Gurpreet Dhillon, *"Principles of Information Systems Security: Texts and Cases"*, John Wiley & Sons, 1st edition, 2006.

Course Title: Time Series Analysis

Course Code: CSLM 636

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	To introduce the concepts of time series analysis and forecasting.
CO-2	To understand stochastic processes and stationary time series models.
CO-3	To analyze spectral methods and forecasting techniques for time series data.
CO-4	To apply non-stationary and long-memory time series models.
CO-5	To understand multivariate time series analysis and volatility modeling techniques.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	1					1	
CO2	1	1	2			2	2
CO3	1	2	2	2	2	2	2
CO4	2	2	2	2	1	2	

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

Syllabus:

Unit I: Introduction to Time Series (7 Hours)
Introduction to time series and its applications. Basic concepts of matrix algebra and regression analysis. Components of time series including trend, seasonal, cyclical, and irregular variations. Methods for trend estimation such as free-hand curve fitting, semi-averages, mathematical curve fitting, and moving averages. Seasonal plots, seasonal subseries plots, box plots, and graphical presentation of cyclical components. Methods for estimating seasonal and irregular components. Exponential smoothing and adaptive forecasting techniques.

Unit II: Time Series Processes and Stationary Models (8 Hours)
Stochastic processes and time series processes. Descriptive measures, process mean and variance, autocovariance function (ACVF), autocorrelation function (ACF), and partial autocorrelation function (PACF). Strong and weak stationarity, ergodicity, deterministic and non-deterministic processes. Wold decomposition theorem. Linear processes, Moving Average (MA), Autoregressive (AR), and ARMA models. Properties, ACF, PACF, Yule-Walker equations, stationarity, and invertibility conditions. Parameter estimation for AR, MA, and ARMA processes.

Unit III: Frequency Domain Analysis and Forecasting (7 Hours)
Fourier transformation and frequency domain representation of time series. Spectral representation and spectral density functions. Spectrum of filtered processes. Cross-spectrum analysis for bivariate processes. Sinusoidal models, periodogram analysis, and estimation of spectral density. Forecasting using stationary and invertible processes. Forecasting with AR, MA, and ARMA models. Diagnostic checking, residual analysis, model validation techniques, Q-test, tests for randomness, and QQ plots.

Unit IV: Non-Stationary and Long Memory Time Series Models (7 Hours)
ARIMA models, random walk processes, unit root problems, Wiener process, and geometric Brownian motion. Unit root testing using Dickey-Fuller, Augmented Dickey-Fuller (ADF), Phillips-Perron, and KPSS tests. Long memory processes and ARFIMA models. Seasonal ARIMA (SARIMA) models. Estimation and interpretation of long-memory and seasonal time series models.

Unit V: Multivariate Time Series and Volatility Modeling (7 Hours)
Multivariate time series processes, cross moments, stationarity, and Wold representation. Cross-spectrum and coherency analysis. Vector Moving Average, Vector Autoregressive, and VARMA models. Forecasting in multivariate processes. Granger causality and causality testing. Cointegration analysis, Engle-Granger procedure, and Johansen test. Introduction to stochastic volatility models, ARCH and GARCH models, parameter estimation, order determination, properties, and forecasting applications.

Learning Resources:

<u>Text Books:</u>
[T1] George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Greta M. Ljung, *"Time Series Analysis, Forecasting and Control"*, Wiley, 5th Edition, 2015.
[T2] Chris Chatfield and Haipeng Xing, *"The Analysis of Time Series: An Introduction with R"*, Chapman and Hall/CRC, 7th Edition, 2019.

<u>Reference Books:</u>
[R1] Peter J. Brockwell and Richard A. Davis, *"Time Series: Theory and Methods"*, Springer-Verlag, 2nd Edition, 2009.
[R2] Jonathan D. Cryer and Kung-Sik Chan, *"Time Series Analysis: With Applications in R"*, Springer, 2nd Edition, 2008.
[R3] James D. Hamilton, *"Time Series Analysis"*, Princeton University Press, Reprint Edition, 2020.

Course Title: Introduction to Cyber Security

Course Code: CSLM 653

L-T-P: 3-0-0

Credits: 3

Pre-requisites: Computer Networks, Operating System

Course Outcomes:

CO-1	Describe the concepts of cybercrime, information security, cyber laws, and intellectual property rights.
CO-2	Examine cyber threats, attack vectors, social engineering techniques, and cybercrime methodologies.
CO-3	Assess security challenges, vulnerabilities, and protection mechanisms in mobile and wireless environments.

Course Articulation Matrix:

COs	PO-1	PO-2	PO-3	PO-4	PO-5	PSO-1	PSO-2
CO1	3	1		1	2	1	1
CO2	3	2		2	1	3	2
CO3	3	2		2	1	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I: Cybercrime (7 Hours)
Definition, Characteristics, and Evolution, Origins of the Term Cybercrime, Information Security Fundamentals. Cybercriminals: Characteristics and Classifications, Global Perspective on Cybercrime, Cybercrime Trends and Challenges, Cyber Offences and Attack Lifecycle, Social Engineering Attacks, Cyber Stalking and Cyber Harassment, Botnets and Attack Vectors Need for Information Security Policies.

Unit II: Introduction to Indian Cyber Law (7 Hours)
Information Technology Act and Related Provisions, Digital Personal Data Protection Act (DPDP), 2023: Objectives and Scope, Privacy and Data Protection, Cyber Ethics and Regulatory Compliance, Intellectual Property Rights in Cyberspace, Patent Protection, Copyright Protection, Trademark Protection, Overview of Intellectual Property Related Legislation in India.

Unit III: Introduction to Mobile (8 Hours)
Wireless Computing, Growth and Trends in Mobile Computing, Mobile Payment and Credit Card Frauds, Security Challenges in Mobile Devices, Authentication and Access Control in Mobile Systems, Threats Attacks on Mobile and Cellular Networks Enterprise Mobile Security Organizational Security Policies for Mobile Environments.

Unit IV: Proxy Servers (7 Hours)
Anonymizers, Phishing Attacks, Identity Theft Techniques, Password Cracking Methods, Keyloggers and Spyware, Viruses and Worms, Trojan Horses and Backdoors, Steganography, Denial of Service (DoS), and Distributed DoS Attacks, SQL Injection Attacks, Buffer Overflow Attacks, Wireless Network Attacks

Unit V: Emerging Cyber Threats (7 Hours)
Cyber Threat Intelligence, Malware Analysis Fundamentals, Security Operations and Incident Response, Digital Forensics Overview, Cloud Security Challenges, IoT Security Issues, AI in Cyber Security, Contemporary Cyber Security Challenges and Future Trends.

Learning Resources:

<u>Text Books:</u>

[T1] Nina Godbole and Sunit Belapure, *"Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives"*, Wiley India, 1st Edition 2013.
[T2] William Stallings and Lawrie Brown, *"Computer Security: Principles and Practice"*, Pearson, 1st Edition.

<u>Reference Books:</u>

[R1] Charles P. Pfleeger and Shari Lawrence Pfleeger, *"Security in Computing"*, Pearson, 5th Edition.
[R2] Papoulis, Athanasios, and S. Unnikrishna Pillai, *"Introduction to Cyber Security"*, Tata McGraw Hill Education, 1st Edition 2002.

Course Title: Database and Online Social Media Security

Course Code: CSLM 654

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	To understand and remember database security, the need of security, and various security models.
CO-2	Identify and apply various types of database security and privacy-preserving techniques.
CO-3	To understand and analyze the basics of online social security threats and the security models used to counter them.
CO-4	Ability to design and implement a security model for Database/ Online social media application.

Course Articulation Matrix:

COs	**POs & PSOs**						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PSO1**	**PSO2**
CO1	3	2	3	2		2	3
CO2	2	2	1		2	3	3
CO3	2	2	2	2		1	1
CO4	1	3	3		2	2	3

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

Syllabus:

Unit – 1
Basics of Security, Security versus Privacy, Introduction to Database Security, Overview of Security Models

Unit–2
Access Control Models, Covert Channels and Inference Channels, Database Intrusion Prevention, Audit, Fault Tolerance, and Recovery

Unit – 3
Privacy-preserving techniques: K-anonymity, L-diversity, Inference control, Privacy-preserving Data Publishing, Identity Theft attacks, Database Applications Security, SQL Injection

Unit – 4

Basics of Online social media and security, OSMs API and tools, Third-party software and attacks, Privacy breaches in OSMs, Phishing

Unit – 5
Case Studies from various domains and Hands-on: MySQL Security / Oracle Security

Learning Resources:

Text Books:

[T1] Eduardo B. Fernandez, Rita C. Summers, Christopher Wood, *"Database Security and Integrity"*, Addison-Wesley Publishing Company, 2007.

[T2] R. Sarma Danturthi, *"Database and Application Security"*, Addison-Wesley Publishing Company, 2024.

Reference Books:

[R1] Hassan A. Afyouni, *"Database Security and Auditing: Protecting Data Integrity and Accessibility, Thomson Course Technology"*, Boston, Mass: Thomson/Course Technology, Indian Edition, 2013.

[R2] Alfred Basta, Melissa Zgola, *"Database Security"*, Delmar Cengage Learning, New Edition (12 July 2011).

[R3] Ivan Bayross, *"Administering Oracle*", BPB, 1 January 2004.

[R4] Bhavani Thuraisingham, *"Database and Applications Security: Integrating Information Security and Data Management"*, Auerbach Publications, 1st edition (26 May 2005).

Other Suggested Readings:

1. IEEE Symposium on Security and Privacy (Conference Proceedings).
2. IEEE Security & Privacy (Magazine)
3. IEEE Transactions on Dependable and Secure Computing (Journal)
   IEEE Transactions on Information Forensics and Security (Journal)
4. ACM Transactions on Information and System Security (Journal)
5. ACM Symposium on Information, Computer and Communications
6. ACM SIGSAC Conference on Computer and Communications Security
7. ACM Conference on Security and Privacy in Wireless and Mobile Networks (Conference Proceedings)
8. ACM Conference on Data and Application Security and Privacy (Conference Proceedings)

ScienceDirect
Elsevier Computers and Security (Journal)
Elsevier Journal of Information Security and Applications (Journal)
Elsevier Network Security (Journal)
SpringerLink
International Journal of Information Security (Journal) Security
Informatics (Journal)
Wiley Online Library
Security and Communication Networks (Journal)

Course Title: Advanced Computer Networks

Course Code: CSBM 661

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	The Advance Computer Network course provides a comprehensive exploration of networking concepts and technologies.
CO-2	Investigate the Internet architecture, IP addressing, routing protocols (RIP, OSPF, BGP), TCP/UDP, DNS, and advanced technologies like SDN, 5G, 6G, and IP security.
CO-3	Implement and optimize network architectures and enhance problem-solving abilities specific to network issues.
CO-4	It equips students with hands-on skills for designing, managing, and troubleshooting modern computer networks.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1	2	1	3	2
CO2	3	3	2	2	1	3	2
CO3	2	2	2	1	2	2	3
CO4	2	3	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Internet Architecture and Network Layer (8 Hours)

Structure of Internet, Intranet, Role of Internet Service Provider (ISP) and Internet Corporation for Assigned Names and Numbers (ICANN), IPv4-Header format, IPv6 -Header format, Subnet, subnet addressing and address masking, super netting, Address Mapping- Address Resolution Protocol (ARP) - Mapping logical to physical addresses, working and message format, Reverse Address Resolution Protocol (RARP) – Mapping physical to logical addresses working and message format.

Unit II: Routing Protocols (8 Hours)

Router architecture, routing table, queueing and switching, Routing protocols- Intra domain routing- Distance vector routing-Creating distance vector routing tables, Initialization, Sharing, Updating- Routing Information Protocol (RIPv2), Link State Routing-Open Shortest Path First (OSPF)-Types of links, Graphical representation, Inter domain Routing-Path Vector Routing-Border Gateway Protocol (BGPv4), Internet Control Message Protocol (ICMP)-Types of messages, Message format, Error reporting messages.

Unit III: Transport Layer Protocols (7 Hours)

Process to Process Delivery-Client/Server paradigm, Multiplexing and Demultiplexing, Connectionless vs. Connection-Oriented Service, User Datagram Protocol (UDP)-Ports-Well known ports for UDP header format, features and applications, Transmission Control Protocol(TCP)-TCP services, TCP features, Segment, Three way handshaking, Flow control, Error control, Congestion control-Open loop, Closed loop, TLS(Transport Layer Security)-working and applications , Stream Control Transmission Protocol (SCTP)- services and features.

Unit IV: Application Layer Protocols (7 Hours)

Domain Name System (DNS) architecture, Domain types, DNS name space, Domain name resolution & mapping to physical addresses, Electronic mail i)Message Transfer Agent -Simple Mail Transfer Protocol (SMTP) Components, Working ii)Message Access Agent - Post Office Protocol (POP) and Internet Message Access Protocol (IMAP), File Transfer Protocol (FTP), Anonymous FTP , Remote logging: Telnet, Remote Desktop , World Wide Web (WWW) and Hyper Text Transfer Protocol (HTTP)- Architecture, Types of web documents, HTTP transaction ,Pretty Good Privacy (PGP)-Security Parameters, Services, A Scenario or Overview of -PGP algorithms, Key rings, PGP certificates.

Unit V: Wireless Network Technologies (6 Hours)

Wireless Network Communication- 3G, 4G, 5G, SDN (Software Defined Network)-Architecture, Working, Applications, Network Functions Virtualization (NFV)-Architecture, Benefits, Applications, Edge Computing and Edge Networking-Definition, Components, Challenges, Applications, Multimedia Wireless Networks – Streaming Audio and Video, Voice Over Internet Protocol (VoIP), Protocols – Realtime Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP).

Learning Resources:

Text Books:

[T1] Tanenbaum Andrew S., Nick Feamster, David J. Wetherall, *"Computer Networks*, Sixth Edition*"*, Pearson ISBN-13: 9780136764052.
[T2] B.M. Harwani & DT Editorial Services, *"Advanced Computer Network"*, Dreamtech ISBN 978-93-5004-013-3.

Reference Books:

[R1] Natalia Olifer, Victor Olifer, "*Computer Networks Principles, Technologies and Protocols For Network Design*", Wiley.
[R2] Thomas D. Nadeau, Ken Gray, *"SDN: Software Defined Networks"*, O'Reilly Media, Inc., ISBN: 9781449342302.
[R3] Kurose, *"Computer Networking, 8th Edition"*, Pearson Education, ISBN-10 9356061319.

Course Title: Distributed Databases

Course Code: CSBM 662

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Study and understand distributed DBMS architecture and distributed database concepts.
CO-2	Identify and apply various stages of distributed query processing.
CO-3	Analyse and evaluate distributed transaction processing, distributed concurrency control, and distributed reliability.
CO-4	Learn NoSQL databases, their types and applicability in different domains.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3		1	1		2	1
CO2	3	3	2	1	1	3	2
CO3	1		2	1	3	3	2
CO4	2	2	2	3	1	3	1

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

Syllabus:

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

Stores, Graph Stores.

Learning Resources:

Text Books:

[T1] Stefano Ceri, Giuseppe Pelagatti, *"Distributed Databases: Principles and Systems"*, Tata McGraw-Hill Education, Indian Edition, 15th Reprint 2018.

[T2] M. Tamer Ozsu, Patrick Valduriez, *"Principles of Distributed Database Systems"*, Springer, Fourth Edition.

[T3] Dan Sullivan, *"NoSQL for Mere Mortals", Addison-Wesley Professional"*, Indian Edition, published 2015.

Reference Books:

[R1] Saeed K. Rahimi, Frank S. Haug, *"Distributed Database Management Systems: A Practical Approach"*, John Wiley & Sons, 2010.

[R2] Paulo Cortez, *"Professional NoSQL"*, Wiley, 2011.

[R3] Pramod Sadalage, Martin Fowler, *"NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence*", Addison-Wesley, 2013.

[R4] Ivan Bayros, *"Administering Oracle"*, BPB Publications, 2006.

Other Suggested Readings:

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.
5. Write the code to create a private database link that points to the remote database named Employee and retrieve information from Employee.
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.
7. Write the code to create a global database link using Oracle Net Manager.
8. Write a Program to implement of Lamport's Logical Clock.
9. Case study on NoSQL.

Course Title: Simulation and Modelling

Course Code: CSBM 663

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Develop mathematical and computational models of real-world dynamic and stochastic systems.
CO-2	Apply random number generation, input modelling, Monte Carlo methods and discrete-event simulation techniques.
CO-3	Design, verify, validate, and analyze simulation experiments using appropriate statistical methods.
CO-4	Implement simulation models using Python/Matlab/SimPy or equivalent tools for AI-DS applications.
CO-5	Evaluate simulation results for optimization, forecasting, digital twins, and data-driven decision-making.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2	2	2	2	1	2	3
CO2	2	3	2	3	2	3	2
CO3	3	3	2	2	2	3	3
CO4	2	3	3	2	3	3	3
CO5	3	3	3	2	3	3	3

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

Syllabus:

Unit I: Foundations of Modelling and Simulation (8 Hours)
System concepts, model classification, static and dynamic models, deterministic and stochastic models, continuous and discrete systems, principles of simulation study, steps in a simulation project, model abstraction, assumptions, performance measures, simulation life cycle, applications in AI and Data Science, limitations, and ethical use of simulation.

Unit II: Randomness, Monte Carlo Simulation, and Input Modelling (8 Hours)
Probability distributions used in simulation, pseudo-random number generation, random variate generation, inverse transform method, acceptance-rejection method, Monte Carlo estimation, variance reduction basics, empirical data analysis, parameter estimation, goodness-of-fit tests, input uncertainty and sensitivity analysis.

Unit III: Discrete-Event Simulation and Queuing Models (8 Hours)
Event scheduling, process interaction and activity scanning approaches, simulation clock, event list, entities, attributes, resources and queues, single-server and multi-server queue models, inventory and reliability models, simulation using Python/SimPy or equivalent tools, collection of time-persistent and customer-average statistics.

Unit IV: Verification, Validation and Output Analysis (6 Hours)
Model verification, calibration, face validation, comparison with real data, transient and steady-state simulation, warm-up period, replication, batch means, confidence intervals, comparison of alternative systems, experimental design, scenario analysis and interpretation of simulation results.

Unit V: Advanced Simulation for AI-DS Applications (6 Hours)

System dynamics modelling, causal loop diagrams, stock-flow models, agent-based modelling, hybrid simulation, data-driven simulation, surrogate modelling, simulation-based optimization, reinforcement learning environments, digital twins, case studies in smart transportation, healthcare, supply chains, manufacturing, and cyber-physical systems.

Learning Resources:

Text Books:

[T1] Jerry Banks, John S. Carson II, Barry L. Nelson, and David M. Nicol, *"Discrete-Event System Simulation"*, Pearson, Fifth Edition, 2010.

[T2] Averill M. Law, *"Simulation Modeling and Analysis"*, McGraw-Hill Education, Fifth Edition, 2014.

Reference Books:

[R1] Byoung Kyu Choi and Donghun Kang, *"Modeling and Simulation of Discrete Event Systems"*, Wiley, First Edition, 2013.

[R2] John D. Sterman, *"Business Dynamics: Systems Thinking and Modeling for a Complex World"*, McGraw-Hill Education, First Edition, 2000.

[R3] Steven F. Railsback and Volker Grimm, *"Agent-Based and Individual-Based Modeling: A Practical Introduction*", Princeton University Press, Second Edition, 2019.

Other Suggested Readings:

List of Experiments:

1. Study and implementation of pseudo-random number generation and basic distribution fitting.
2. Implementation of Monte Carlo simulation for numerical estimation and risk analysis.
3. Simulation of a single-server and multi-server queuing system.
4. Discrete-event simulation of inventory or service system using SimPy/MATLAB/AnyLogic equivalent.
5. Input data analysis, parameter estimation and goodness-of-fit testing for simulation data.
6. Verification and validation of a simulation model using observed/sample data.
7. Output analysis using replications, confidence intervals and comparison of two alternatives.
8. System dynamics model using causal loop and stock-flow representation.
9. Agent-based simulation for traffic, crowd, epidemic or market behaviour.
10. Mini project/case study on simulation-based decision support for an AI-DS application.

Course Title: Randomized Algorithms

Course Code: CSLM 664

L-T-P: 3-1-0

Credits: 4

Pre-requisites: Probability, Statistics, Stochastic Processes and Discrete Mathematics

Course Outcomes:

CO-1	Construct and Analyze algorithms using a probabilistic framework. (Analyze)
CO-2	Assess the computational hardness of a problem with a comprehension of the randomized complexity classes. (Analyze)
CO-3	Construct Las Vegas algorithms for a given problem and compute the expected running time. (Analyze)
CO-4	Construct Monte-Carlo algorithms for a given problem and compute the probability of getting an incorrect output. (Analyze)
CO-5	Design and analyze solutions for complex problems using randomization design paradigms like Foiling the Adversary, Abundance of Witnesses, Fingerprinting, Random Sampling, Amplification and Random Rounding. (Analyze)

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1		1	2	1
CO2	3	3	2	1	2	3	2
CO3	3	3	3	2	2	3	3
CO4	3	3	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module-1: Introduction to Randomized Algorithms
Review on Algebra, Number theory, Combinatorics and Probability theory, Probabilistic analysis of Algorithms, Randomized Complexity classes and hardness of problems, Randomness as a source of efficiency- designing a communication protocol, Models of Randomized Algorithms, Classification-Las Vegas, Monte-Carlo (one-sided error, bounded-error, and unbounded-error), Classification of Randomized Algorithms for Optimization problems.

Module-II: Design Paradigms
Foiling the Adversary, Abundance of Witnesses, Fingerprinting, Random Sampling, Amplification, Random Rounding.

Module-III: Representative Algorithms
Foiling the Adversary – Universal Hashing, Fingerprinting Communication protocols, Verification of Matrix Multiplication, Equivalence of Two polynomials, Success

Amplification and Random Sampling – Min-Cut, Satisfiability and repeated random sampling, Abundance of Witnesses and Optimization & random rounding – Primality Testing, Max-SAT review, hybrid sampling & rounding, Derandomization Techniques.

Learning Resources:

<u>Text Books:</u>

[T1] Juraj Hromkovic, "*Design and Analysis of Randomized Algorithms*", First edition, Springer, 2005.

[T2] Rajeev Motwani, Prabhakar Raghavan, "*Randomized Algorithms*", Cambridge University Press, 1995.

[T3] Charles E. Leiserson, Thomas H. Cormen, Ronald L. Rivest and Clifford Stein, "*Introduction to Algorithms*", third edition, PHI, 2010.

Course Title: Parallel Algorithms

Course Code: CSLM 665

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Understand parallel computation models.
CO-2	Apply algorithm design strategies to implement core parallel algorithms.
CO-3	Understand parallel solutions for graph and combinatorial problems.
CO-4	Evaluate parallel algorithms on modern architectures and Frameworks.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2	1	2	2	3	1	1
CO2	3	2	2	3	2	2	3
CO3	2	2	3	3	3	3	3
CO4	1	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Foundations of Parallel Computation (6 Hours)
Models of parallel computation: Parallel Random-Access Machine (PRAM), Bulk Synchronous Parallel (BSP), Latency, Overhead, Gap, and Processors (LogP). Complexity measures: Work, Depth, Speedup, Efficiency, Scalability. Cost-optimality and Brent's Theorem. Algorithm design strategies: partitioning, pipelining, divide-and-conquer.

Unit II: Core Parallel Algorithms (6 Hours)
Parallel prefix (Scan), reduction, and list ranking. Parallel sorting: Bitonic sort, Parallel quicksort, Sample sort. Searching and selection algorithms. Matrix operations: multiplication, transposition, prefix sums. Fast Fourier Transform (FFT) in parallel.

Unit III: Graph and Combinatorial Algorithms (8 Hours)
Parallel graph traversal: Breadth-First Search (BFS), Depth-First Search (DFS). Connected components detection. Minimum spanning tree algorithms: Borůvka's, parallel Kruskal, parallel Prim. Shortest paths: Dijkstra, Bellman-Ford, Floyd-Warshall in parallel. Graph coloring and matching.

Unit IV: Advanced Paradigms and Randomization (8 Hours)
Parallel dynamic programming. Parallel string matching and regular languages. Randomized parallel algorithms. Parallel approximation algorithms. Applications in Machine Learning: Parallel Stochastic Gradient Descent (SGD), Deep Learning training.

Unit V: Architectures, Frameworks, and Applications (8 Hours)
Shared memory vs. distributed memory systems. Multicore, Graphics Processing Unit (GPU), and heterogeneous computing. Big data frameworks: MapReduce, Apache Spark. Case studies in scientific computing, precision agriculture, and environmental monitoring. Emerging paradigms: quantum-inspired parallelism, neuromorphic computing.

Learning Resources:

Text Books:

[T1] F. T. Leighton, "*Introduction to Parallel Algorithms and Architectures: Arrays, Trees, Hypercubes*", Morgan Kaufmann, 2014.
[T2] M. J. Quinn, "*Parallel Programming in C With Mpi and Openmp*", McGraw-Hill Science Engineering, 2023.
[T3] J. JaJa, *"Introduction to Parallel Algorithms"*, Pearson Education India, First Edition, 1992.

Reference Books:

[R1] A. Grama, G. Karypis, V. Kumar and A. Gupta, "*Introduction to Parallel Computing: Design and Analysis of Algorithms*", Addison-Wesley, Second Edition, 2003.
[R2] T. Rauber and G. Runger, "*Parallel Programming: for Multicore and Cluster Systems*", Springer International Publishing AG, Third Edition, 2023.
[R3] J. L. Hennessy, D. A. Patterson, and C. Kozyrakis, "*Computer Architecture: A Quantitative Approach*", Morgan Kaufmann, Seventh Edition, 2025.
[R4] T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, "*Introduction to Algorithms*", MIT PRess, Fourth Edition, 2022.

Course Title: Computational Complexity

Course Code: CSLM 666

L-T-P: 3-1-0

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Understand models of computation (Turing Machine) and describe complexity measures (time, space, asymptotic notation).
CO-2	Analyze polynomial-time reductions and differentiate between classes P, NP, co-NP, and PSPAC.
CO-3	Apply approximation and randomized strategies.
CO-4	Evaluate space complexity classes and design solutions.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2	1	2	2	3	1	1
CO2	3	3	3	3	3	3	3
CO3	3	2	2	3	2	2	3
CO4	1	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Introduction to Computational Complexity (6 Hours)
Models of computation: Turing Machine (TM). Review of asymptotic notation: Big-O, Big-Ω (Omega), Big-Θ (Theta). Time complexity and Space complexity. Complexity classes: Polynomial Time (P) and Nondeterministic Polynomial Time (NP). Polynomial-time verification. The P vs. NP.

Unit II: NP-Completeness and Reductions (6 Hours)
Polynomial-time reductions. Cook–Levin Theorem. Classic NP-Complete problems: Boolean Satisfiability Problem (SAT), 3-Clause Satisfiability (3-SAT). Clique, Vertex Cover, Independent Set. Hamiltonian Cycle. Traveling Salesperson Problem (TSP).

Unit III: Advanced Complexity Classes and Algorithmic Strategies (8 Hours)
NP-Hard problems. Complement of NP (co-NP). Polynomial Space (PSPACE) and PSPACE-Completeness. Exponential Time (EXPTIME). Introduction to Approximation Algorithms: Vertex Cover, TSP, Set Cover. Randomized complexity classes: Randomized Polynomial Time (RP), Bounded-Error Probabilistic Polynomial Time (BPP), Zero-Error Probabilistic Polynomial Time (ZPP).

Unit IV: Space Complexity and Practical Applications (8 Hours)

Savitch’s Theorem. Logarithmic space classes: Logarithmic Space (L) and Nondeterministic Logarithmic Space (NL). Introduction to Parameterized Complexity. Practical aspects: Modeling real-world problems as SAT instances. Introduction to modern SAT/SMT (Satisfiability Modulo Theories) solvers.

Unit V: Emerging Paradigms and Applications (8 Hours)
Parallel complexity classes: Nick’s Class – problems solvable in polylogarithmic time on a polynomial number of processors (NC), P-Complete problems. Circuit complexity and depth. Case studies: Applications in cryptography, artificial intelligence, big data, and precision agriculture.

Learning Resources:

Text Books:

[T1] S. Arora, “*Computational Complexity: A Modern Approach*”, Cambridge University Press, First Edition, 2009.
[T2] C. Papdimitriou, “*Computational Complexity*”, Pearson, First Edition, 1993.
[T3] M. Sipser, *“Introduction to The Theory of Computation”*, Cengage India Private Limited, Third Edition, 2014.
[T4] M. R. Garey and D. S. Johnson, “*Computers and Intractability: A Guide to the Theory of Np-Completeness*” W H Freeman & Co, 1979.

Reference Books:

[R1] O. Goldreich, “*Computational Complexity a Conceptual Perspective*”, Cambridge University Press, 2012.
[R2] D. Du, and K. Ko, “*Theory of Computational Complexity*”, Wiley, Second Edition, 2014.
[R3] J. L. Balcazar, J. Diaz, and J. Gabarro, “*Structural Complexity I, II and III”*, Springer, Seventh Edition, 2012.

Course Title: Network and Wireless Security

Course Code: CSBM 671

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain the fundamental concepts of network security, security services, security models, and common network threats and attacks.
CO-2	Apply cryptographic techniques, authentication mechanisms, and key management schemes to secure communication systems.
CO-3	Analyze wireless network architectures and evaluate security protocols, vulnerabilities, and countermeasures in wireless environments.
CO-4	Design and implement network defense mechanisms using firewalls, IDS/IPS, VPNs, and security monitoring tools to protect network infrastructures.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2	1	1	2	1	2	1
CO2	3	1	1	2	2	3	1
CO3	3	2	2	3	2	3	1
CO4	2	2	2	3	2	2	1

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

Syllabus:

Unit I: Introduction to Network Security (8 Hours)
Fundamentals of Network Security, Security Goals: Confidentiality, Integrity, Availability (CIA Triad), Types of Security Threats and Attacks, OSI and TCP/IP Security Models, IP Addressing and Subnetting, Network Devices: Hubs, Switches, Routers, Firewalls, Network Protocols and Services (HTTP, HTTPS, FTP, SSH).

Unit II: Cryptography and Authentication (9 Hours)
Introduction to Cryptography, Symmetric and Asymmetric Key Cryptography, Data Encryption Standard (DES), Advanced Encryption Standard (AES), RSA Algorithm, Hash Functions, Message Authentication Codes (MAC), Digital Signatures, Public Key Infrastructure (PKI), Authentication Protocols, Multi-Factor Authentication, Key Management and Distribution.

Unit III: Wireless Network Security (8 Hours)

Wireless Network Fundamentals, IEEE 802.11 WLAN Architecture, Wireless LAN Security, Bluetooth Security, RFID Security, Wireless Security Protocols: WEP, WPA, WPA2, and WPA3, Mobile IP Security, Wireless Threats and Attacks, Rogue Access Points, Wireless Intrusion Detection Systems, Securing Mobile and Wireless Devices.

Unit IV: Network Defense and Security Applications (9 Hours)
Firewalls and Firewall Architectures, Packet Filtering and Stateful Inspection, Intrusion Detection Systems (IDS), Intrusion Prevention Systems (IPS), Virtual Private Networks (VPNs), Malware and Anti-Malware Techniques, Security Monitoring and Log Analysis, Incident Response and Digital Forensics, Security in Cloud and Mobile Computing Environments, Emerging Trends in Network and Wireless Security.

Learning Resources:

<u>Text Books:</u>
[T1] William Stallings, *"Cryptography and Network Security: Principles and Practice"*, Pearson Education, 8th Edition, 2022.
[T2] William Stallings, *"Network Security Essentials: Applications and Standards"*, Pearson Education, 7th Edition, 2017.

<u>Reference Books:</u>
[R1] Behrouz A. Forouzan, *"Cryptography and Network Security"*, McGraw-Hill Education, 3rd Edition, 2015.

List of Experiments:

1. Study of basic networking tools and commands (Ping, Tracert, Netstat, Nslookup, Ipconfig/Ifconfig).
2. Configuration and analysis of IP addressing and subnetting in a network environment.
3. Implementation of symmetric key cryptography algorithms (DES/AES) for secure communication.
4. Implementation of asymmetric key cryptography algorithms (RSA) and key generation.
5. Simulation and analysis of common network attacks such as DoS, spoofing, and sniffing using network simulation tools.
6. Wireless network setup and security configuration using WEP, WPA2, and WPA3 protocols.
7. Capturing and analyzing network packets using Wireshark.
8. Configuration and testing of Virtual Private Networks (VPNs) for secure remote access.
9. Security assessment and vulnerability scanning using tools such as Nmap and OpenVAS.
10. Implementation of authentication and access control mechanisms in a network environment.
11. Mini Project: Design and implementation of a secure wired/wireless network incorporating firewall, VPN, encryption, and intrusion detection mechanisms.

Course Title: Queuing Theory

Course Code: CSLM 672

L-T-P: 3-1-0

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Explain the fundamentals, structure, and characteristics of queuing systems.
CO-2	Demonstrate arrival processes, service mechanisms, queue disciplines and Kendall-Lee notation.
CO-3	Apply single-server queuing models for evaluating waiting time, queue length and utilization.
CO-4	Design and simulate real-world queuing systems using analytical and computational tools.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	1	1		1	2	1
CO2	3	2	2	2	2	2	2
CO3	3	3	2	2	2	3	2
CO4	2	3	3	3	2	3	2
CO5	2	3	3	3	3	3	3

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

Syllabus:

Unit I: Introduction to Queuing Theory and Queuing System Structure (8 Hours)
Introduction to queuing theory; need and applications of queuing models; basic structure of a queuing system; input source and calling population; finite and infinite population; arrival process; service mechanism; single-server and multi-server systems; queue discipline: FCFS, SIRO, priority, and random service; steady-state and transient-state behaviour; Kendall-Lee notation; classification of queuing models.

Unit II: Probability Distributions and Birth-Death Process (8 Hours)
Review of probability concepts used in queuing theory; random variables and probability distributions; Poisson arrival process; exponential inter-arrival and service-time distribution; memoryless property; Markov process; birth-death process; transition rates; balance equations; steady-state probabilities; stability condition and utilization factor.

Unit III: Single-Server Queuing Models (8 Hours)

Analysis of single-server queuing models; M/M/1: infinity/FCFS model; M/M/1: N/FCFS finite-capacity model; M/M/1: infinity/SIRO model; M/D/1, M/G/1 and M/Ek/1 overview; probability of zero units in the system; probability of n units in the system; expected queue length; expected number in the system; waiting time in queue and system; probability of waiting; idle time and busy period; numerical problem solving.

Unit IV: Multi-Server and Advanced Queuing Models (8 Hours)
Multiple-server queuing models; M/M/K: infinity/FCFS model; M/M/K: N/FCFS finite-capacity model; probability of empty system; average queue length; average number of units in the system; average waiting time; server utilization; comparison of single-server and multi-server systems; priority queues; finite population model; cost-based queuing decisions; service capacity planning.

Unit V: Queuing System Analysis and Computational Modelling (4 Hours)
Queuing models in banking, healthcare, call centers, traffic systems, manufacturing, computer networks, cloud computing, and service industries; modelling of arrival and service-time processes; random number generation; evaluation of waiting time, queue length, server utilization, and system efficiency using Python/MATLAB/Excel.

Learning Resources:

Text Books:

[T1] Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris, *"Fundamentals of Queueing Theory"*, Wiley, 4/E.
[T2] Hamdy A. Taha, *"Operations Research: An Introduction"*, Prentice Hall of India, 7/E, 2003.

Reference Books:

[R1] Ravindran, Phillips and Solberg, *"Operations Research: Principles and Practice"*, John Wiley & Sons, 2/E.
[R2] D. S. Hira, *"Operations Research"*, S. Chand & Company Ltd., 2004.
[R3] Leonard Kleinrock, *"Queueing Systems, Volume 1: Theory"*, Wiley-Interscience, 1/E.

List of Tutorials:

1. Study and implementation of basic queuing system parameters using Python/MATLAB.
2. Generate and analyse Poisson arrivals and exponential service-time distribution.
3. Implement the M/M/1: infinite/FCFS queuing model and calculate utilization, P0 and Pn.
4. Calculate Lq, L, Wq and W for a single-server queuing system.
5. Implement and analyse the M/M/1: N finite-capacity queuing model.
6. Simulate service-in-random-order and priority-based queuing disciplines.
7. Implement the M/M/K: infinite/FCFS multiple-server queuing model.
8. Compare single-server and multi-server queuing systems for the same arrival rate.
9. Perform service-rate/capacity decision analysis using queuing cost considerations.
10. Simulate a real-world queuing system such as bank counter, hospital OPD, ticket counter or call centre.

Course Title: Wireless Sensor Networks

Course Code: CSLM 673

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Describe the overview of wireless sensor networks and its enabling technologies.
CO-2	Understand the WSN coverage and Topology management.
CO-3	Apply WSN concepts for assignment of MAC addresses and understand the need of WSN security.
CO-4	Analyze the sensor network platform and tools state-centric programming.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	2					1	
CO2	2	2	2				3
CO3	3				2	2	
CO4		2			2	2	

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

Syllabus:

Unit I: Introduction to Wireless Sensor Network (8 Hours)
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.

Unit II: WSN Coverage Area (8 Hours)
Area coverage, Point Coverage, Barrier Coverage, Coverage Maintenance, Sensor Placement, Topology Management in WSN, Types of WSN, WSN Algorithms, MANETs.

Unit III: Networking (8 Hours)
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.

Unit IV: Security (8 Hours)
Need of Security in Wireless Sensor Networks, Types of Keying Mechanisms for WSN,

Security requirement in WSN, WSN attacks, and Security protocols for WSNs.

Unit V: Platforms and Tools (7 Hours)
Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node-level software platforms, Node level Simulators, State-centric programming.

Learning Resources:

Text Books:
[T1] Holger Karl, Andreas Willig, *"Protocols and Architectures for Wireless Sensor Networks"*, John Wiley, 2005.
[T2] Waltenegus Dargie, Christian Poellabauer, *"Fundamentals of Wireless Sensor Networks - Theory and Practice"*, John Wiley & Sons Publications, 2011.

Reference Books:
[R1] Ian F. Akyildiz, Mehmet Can Vuran, *"Wireless Sensor Networks"*, John Wiley & Sons, First Edition, 2011.
[R2] Anna Hac, *"Wireless Sensor Network Designs"*, John Wiley & Sons, First Edition, 2013.

Course Title: Next Generation Networks

Course Code: CSLM 674

L-T-P: 3-0-0

Credits: 3

Pre-requisites: Computer Network

Course Outcomes:

CO-1	Develop the basic knowledge of NGN, its building blocks, and various services.
CO-2	Understand IP networks, LAN and WAN technologies and topologies.
CO-3	Study concept of ATM, MPLS and multiservice networks.
CO-4	Understand various NGN application.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1	2	1	3	2
CO2	3	3	2	2	1	3	2
CO3	2	2	2	1	2	2	3
CO4	2	3	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Unit I: Introduction of Next generation networks (8 Hours)
Introduction to next generation networks. Communicating in the new Era, New Era of Networking, Technologies influencing change, IP Everywhere, Optical fiber anywhere, wireless access, building blocks for NGN, IP Networks, VOIP, Multi service Flexible Networks architecture. VPNs, Optical Networks, Wire line & Wireless Networks, NGN Services, Network Infrastructure convergence, services convergence, from technology push to service pull.

Unit II: IP-Based Network Technologies (8 Hours)
IP Networks, IP past, present and future, IP influence and confluence, IP version 4, I. P. Version 6, IP Network convergence, LAN Technologies, IP Routing, LAN Switching, WAN's, WAN Technologies, and Topologies. Wireless IP LANS, Mobility Networks, Global IP Networks, Global capacity, Globally Resilient IP, Internet – A Network of Networks. Beyond IP, Technology Brief – IP Networks, Business Drivers, Success factors, Applications and Service Value, MPLS Architecture and Applications, Software Defined Networking (SDN), Network Function Virtualization (NFV).

Unit III: Muti service Networks (7 Hours)
Muti service Networks Origin of multi service ATM, Next Generation Multi service Networks, Next Generation Multi service ATM switching, Multi-protocol Label switching, Networks, Frame Based MPLS, Cell based MPLS, MPLS services and their benefits, multi service provisioning platforms (MSPP) & Multi service switching platform (MSSP).

Unit IV: Application of Next Networks (7 Hours)
NGN Applications Internet connectivity, e-commerce, call center, third party application service provision, UMTS, WAP, WiMAX, integrated billing, security, and directory enabled networks.

Unit V: Emerging Trends in NGN (6 Hours)
Cloud Networking, Artificial Intelligence in Network Management, Network Automation and Orchestration, Future Internet Architectures, 6G Vision and Applications, Wireless Network Communication- 3G, 4G, 5G, Edge Computing and Edge Networking-Definition, Components, Challenges, Applications, Multimedia Wireless Networks – Streaming Audio and Video, Voice Over Internet Protocol (VoIP), Protocols – Realtime Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP).

Learning Resources:

<u>Text Books:</u>

[T1] Neill Wilkinson, "*Next Generation Networks Services, Technologies and Strategies*", Wiley.
[T2] Robet Wood, "*Next Generation Network Services*", Pearson.

<u>Reference Books:</u>

[R1] Miguel Barreiros, Peter Lundqvist, "*QOS-Enabled Networks: Tools and Foundations*", Wiley, 2nd edition, 2016.
[R2] Thomas D. Nadeau, Ken Gray, *"SDN: Software Defined Networks"*, O'Reilly Media, Inc. ISBN: 9781449342302.
[R3] T.G. Robertazzi, "*Computer Networks and Systems: Queuing Theory and Performance Evaluation*", 3rd edition, Springer, 2000.

Course Title: Mobile Computing

Course Code: CSLM 675

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Explain the fundamentals of mobile computing, wireless telephony systems, cellular architecture, GSM, CDMA, GPRS, and mobility management techniques.
CO-2	Analyze wireless networking technologies, IEEE 802.11 standards, Bluetooth architecture, wireless access protocols, Mobile IP, and WAP-based mobile communication systems.
CO-3	Apply data management techniques in mobile computing environments, including data replication, adaptive clustering, file systems, and disconnected operations.
CO-4	Evaluate the role of mobile agents, security mechanisms, fault tolerance techniques, and transaction processing in mobile computing systems.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3			3	2	2	2
CO2	3	2		3	2	2	2
CO3	3	3	1	3	2	2	2
CO4	3	3	2	3	2	2	2

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

Syllabus:

Module I (8 Hours)
Introduction, issues in mobile computing, overview of wireless telephony: cellular concept, GSM, channel structure, location management: HLR-VLR, hierarchical, handoffs, channel allocation in cellular systems, CDMA, GPRS.

Module II (8 Hours)
Wireless Networking, Wireless LAN Overview: MAC issues, IEEE 802.11, Bluetooth, Wireless multiple access protocols, TCP over wireless, Wireless applications, data broadcasting, Mobile IP, WAP: Architecture, protocol stack, application environment, applications.

Module III (8 Hours)

Database Issues: Hoarding techniques, caching invalidation mechanisms, client-server computing with adaptation, power-aware and context-aware computing, transactional models, query processing, recovery, and quality-of-service issues, Data replication for mobile computers, adaptive clustering for mobile wireless networks, file systems, and disconnected operations.

Module IV (8 Hours)
Mobile Agents computing, security, and fault tolerance, transaction processing in a mobile computing environment, Mobile agent – Application server – Gateways – Portals -Service Discovery – Device management – Mobile file systems-Security. Mobile Ad Hoc and Wireless 16 Sensor Networks-Introduction to mobile Ad hoc network – MANET –Wireless Sensor Networks –Applications

Learning Resources:

<u>Text Books:</u>

[T1] Jochen Schiller, *"Mobile Communications"*, Pearson Education, Second Edition, 2003.
[T2] Raj Kamal, "Mobile Computing", Oxford University Press, Second Edition, 2010.

<u>Reference Books:</u>

[R1] Asoke K. Talukder and Roopa R. Yavagal, *"Mobile Computing: Technology, Applications and Service Creation"*, Tata McGraw-Hill, Second Edition, 2010.

Course Title: Network and Data Security

Course Code: CSBM 678

L-T-P: 3-0-2

Credits: 4

Pre-requisites:

Course Outcomes:

CO-1	Identify the key security requirements of confidentiality, integrity, and availability, security architecture for OSI, categories of computer and network assets, fundamental security design principles, and cryptography standards.
CO-2	Interpret knowledge of symmetric and asymmetric ciphers, classical encryption techniques, block ciphers and data encryption standard, and public key cryptography.
CO-3	Categorize cryptographic data integrity algorithms, cryptographic, hash function, message authentication codes, digital signatures, and user authentication.
CO-4	Extend network access control and cloud security, transport level security, wireless network security, electronic mail security and IP security and evaluate the principles of Network Security in real time applications.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	2	2	2	2	2
CO2	2	2	2		2	2	2
CO3	3	2			2	2	2
CO4	3	2	2	2	2	2	2

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

Syllabus:

Unit I: Introduction (6 Hours)
Network Security Model, OSI Security Architecture, Goals of network security and standard, Basic concepts of cryptography, Introduction to IT-Security in Open system, threats to security, security requirements and how it works.

Unit II: Protocol Vulnerabilities (7 Hours)
DoS and DDoS, SYN Flooding, Session Hijacking, ARP Spoofing, Attack on DNS. Wireless LAN: Frame spoofing, Violating MAC; Software Vulnerabilities: Phishing Attack, Buffer Overflow, Cross-site Scripting, SQL Injection; Virus, Worm, Malware, Botnets; Eavesdropping, Password Snooping, and IP Masquerade

Unit III: Authentication (8 Hours)

Password-based, certificate-based, Centralized; Kerbos, Biometrics., SSL, IP Security, IKE, Virtual Private Network, Open SSL, Wireless LAN Security: WEP, TKIP, CCMP.

Unit IV: Firewall (8 Hours)

Introduction to Firewall, Firewall Functionalities, Types of Firewalls, Packet Filtering, Reverse Proxy, Stateful Firewalls, limitation of Stateful Firewall's, Application Firewalls, Circuit Firewalls, CHECK Point, CISCO PIX, CISCO firewalls case study.

Unit V: Electronic Payment (7 Hours)

Electronic Payment: Payment types, SET, Chip Card Transaction, Mobile Payments; Electronic Mail Security, Web Security: SSL and TLS, Web Service Security: Token Type, XML Encryption, XML Signatures, SAML; Intrusion detection and prevention systems; honey pots.

Learning Resources:

Text Books:

[T1] Bernard Menezes, *"Network Security and Cryptography"*, Cengage Learning, First Edition, 2010.

Reference Books:

[R1] Willam Stallings, *"Cryptography and Network Security"*, Pearson Education, Seventh Edition, 2017.
[R2] Steven Galbraith, *"Mathematics of Public Key Cryptography"*, Cambridge University Press, 2012.
[R3] Raymond R. Panko, *"Corporate Computer and Network Security"*, Pearson Education, Second Edition, 2009.

List of Experiments:

1. Study of different wireless network components and features of any one of the Mobile Security Apps.
2. Study of the features of firewall in providing network security and to set Firewall Security in windows.
3. Steps to ensure Security of any one web browser (Mozilla Firefox/Google Chrome).
4. Study of different types of vulnerabilities for hacking websites / Web Applications.
5. Analysis of the Security Vulnerabilities of E-commerce services.
6. Analysis of the security vulnerabilities of E-Mail Application.

Course Title: Information Theory and Coding

Course Code: CSLM 677

L-T-P: 3-0-0

Credits: 3

Pre-requisites:

Course Outcomes:

CO-1	Explain entropy, joint/conditional entropy, relative entropy, and mutual information for discrete and continuous sources.
CO-2	Apply source coding and data compression principles including Huffman, Shannon-Fano, arithmetic and rate-distortion coding.
CO-3	Analyse channel models, channel capacity and coding limits for reliable communication over noisy channels.
CO-4	Design and evaluate error control codes such as linear block, cyclic, BCH, Reed-Solomon, convolutional and modern iterative codes for practical systems.

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	1		1	2	1
CO2	3	3	2	1	2	3	2
CO3	3	3	3	2	2	3	3
CO4	3	3	3	2	3	3	3

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

Syllabus:

Unit I: Information Measures and Sources (7 Hours)
Information, uncertainty, and entropy; joint entropy, conditional entropy, and chain rules; relative entropy, mutual information, and data processing inequality; entropy rate of stochastic processes; typical sequences; discrete and continuous sources; information measures in machine learning and data science.

Unit II: Source Coding and Compression (7 Hours)
Source coding theorem; uniquely decodable and instantaneous codes; Kraft-McMillan inequality; Shannon-Fano coding, Huffman coding and arithmetic coding; Lempel-Ziv coding basics; universal coding; lossy compression, distortion measures and rate-distortion function; applications in text, image, and multimedia data compression.

Unit III: Channel Models and Capacity (7 Hours)
Communication channel models; binary symmetric channel, binary erasure channel and Gaussian channel; channel capacity and capacity computation; noiseless and noisy channel coding theorems; mutual information maximization; bandwidth, signal-to-noise ratio, and Shannon capacity; introduction to network information theory concepts.

Unit IV: Linear Block and Cyclic Codes (8 Hours)
Error detection and correction principles; Hamming distance and minimum distance decoding; generator and parity-check matrices; syndrome decoding; Hamming codes; cyclic codes and polynomial representation; BCH codes; Reed-Solomon codes; interleaving, burst-error correction, and practical storage/communication applications.

Unit V: Convolutional and Modern Coding Techniques (7 Hours)
Convolutional codes; state diagram, trellis representation and Viterbi decoding; sequential decoding concepts; concatenated codes; Turbo codes, LDPC codes and iterative belief-propagation decoding; coding for wireless, IoT, cloud storage and secure AI/data systems; performance measures including bit error rate, code rate, coding gain and complexity.

Learning Resources:

<u>Text Books:</u>
[T1] Thomas M. Cover and Joy A. Thomas, *"Elements of Information Theory"*, Wiley, Second Edition, 2006.
[T2] Ranjan Bose, *"Information Theory, Coding and Cryptography"*, Tata McGraw Hill Education, Second Edition, 2008.

<u>Reference Books:</u>
[R1] Shu Lin and Daniel J. Costello Jr., *"Error Control Coding: Fundamentals and Applications"*, Prentice Hall / Pearson, Second Edition, 2004.