

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Technology - Programmes offered at the Department of Computer Science - Resolution of the Academic Council - Communicated - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/4081/2024

Dated,KOCHI-22,26.09.2024

Read:-Item No. I (f) (8) of the minutes of the meeting of the Academic Council held on 30.04.2024

ORDER

The Academic Council considered along with the recommendations of its standing committee, the Minutes of the Faculty of Technology held on 08.04.2024 and resolved to approve the following :

i. Revised Scheme and Syllabus of M.Tech Computer Science & Engineering with Specialization in Data Science and Artificial Intelligence (Full-Time Programme) with effect from 2024 admissions (Appendix I).

ii. Revised Scheme and Syllabus of M.Tech Computer Science & Engineering (Artificial Intelligence and Software Engineering) (Full-Time Programme) with effect from 2024 admissions (Appendix II).

iii. Revised Scheme and Syllabus of M.Tech Computer Science & Engineering (Data Science and Artificial Intelligence) (Part-Time Programme) with effect from 2025 admissions (Appendix III).

iv. Revised Scheme and Syllabus of Five Year Integrated M.Sc in Computer Science (Artificial Intelligence and Data Science) (Appendix IV).

v. Amendment to clause 9.4 of M.Tech Regulation, 2020 as,

9.4(a) A student of the Full-Time M.Tech programme shall acquire a minimum of 28 credits in the first two semesters before he/she registers for the third semester.

9.4(b) The minimum credit requirement mentioned in 9.4(a) is not applicable to the Part-Time M.Tech programme.

9.4(c) A student shall complete the M.Tech programme in 8 consecutive semesters in the case of Full-Time programmes and 10 consecutive semesters in the case of Part-Time programme by acquiring a minimum total credit requirement of 72.

vi. Awarding of B.Sc and M.Sc degree to 2021 & 2022 batch students:

To award B.Sc in Computer Science Degree to those students who successfully completes 6 semesters and to award M.Sc (Five Year Integrated) in Computer Science (Artificial Intelligence and Data Science) to those whose successfully completes 10 semesters. This is applicable to 2021 & 2022 admissions only.

Orders are issued accordingly.

Dr. Arun A U *
Registrar

To:

1. The Dean, Faculty of Technology
2. Chairperson, BoS under Faculty of Technology
3. The Head, Department of Computer Science
4. All AR/DR Examination wing - with a request to forward to concerned sections
5. The Director, IQAC/ DoA
6. CIRM/Conference Sections
7. PS To VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY



DEPARTMENT OF COMPUTER SCIENCE

PROGRAMME STRUCTURE & SYLLABUS [2024 ADMISSION ONWARDS]

M.TECH. COMPUTER SCIENCE & ENGINEERING WITH SPECIALIZATION IN DATA SCIENCE & ARTIFICIAL INTELLIGENCE

**SYLLABUS FOR
OUTCOME BASED EDUCATION**

**MASTER OF TECHNOLOGY (M.TECH.) COMPUTER SCIENCE &
ENGINEERING WITH SPECIALIZATION IN DATA SCIENCE &
ARTIFICIAL INTELLIGENCE**

(2024 admission onwards)

Program Outcomes (PO) For The M.Tech. Computer Science & Engineering With Specialization in Data Science & Artificial Intelligence

After the completion of M.Tech. programme, the students will be able to:

PO1: Elicit deeper and current knowledge through research/exploration leading to development work with a motivation to solve practical problems.

PO2: Communicate effectively through well-written technical documentation as well as audio-visual Presentations.

PO3: Recognize the importance of entrepreneurship and innovation to create value and health.

PO4: Acquire mastery in the topic of study at an exceedingly higher level.

Program Specific Outcomes (PSO) For The M.Tech. Computer Science & Engineering With Specialization in Data Science & Artificial Intelligence

At the end of the programme students will be able to:

PSO1: Attain comprehensive understanding of advanced theories and models in Computer Science, Data Science and Artificial Intelligence.

PSO2: Design, implement, and evaluate AI models and systems for real-world applications in diverse domains.

PSO3: Realize data science pipeline by integrating data engineering, analytics, and visualization for enterprise solutions

PSO4: Enhance research skills and conduct independent research, which could lead to technological innovations and improvements in the field of AI and Data Science

| DEPARTMENT OF COMPUTER SCIENCE | | | | | | | |
|--|-------------|--|-----------------|-------------------------|-----|--------------|-------|
| PROGRAMME STRUCTURE AND SYLLABUS (2024 ADMISSIONS) | | | | | | | |
| M. TECH. COMPUTER SCIENCE & ENGINEERING | | | | | | | |
| WITH SPECIALIZATION IN DATA SCIENCE & ARTIFICIAL INTELLIGENCE | | | | | | | |
| Semester - I | | | | | | | |
| Sl. No. | Course code | Course Title | Core / Elective | Credits | Lec | Lab/Tutorial | Marks |
| 1 | 24-479-0101 | Mathematics for Computing | C | 4 | 4 | 2 | 100 |
| 2 | 24-479-0102 | Artificial Intelligence and Machine Learning | C | 4 | 4 | 2 | 100 |
| 3 | 24-479-0103 | Design and Analysis of Algorithms | C | 4 | 4 | 2 | 100 |
| 4 | - | Elective I | E | 3 | 4 | 2 | 100 |
| 5 | - | Elective II | E | 3 | 4 | 2 | 100 |
| Total for Semester I | | | | 18 | 20 | 10 | 500 |
| Electives | | | | | | | |
| 24-479-0104: Advanced Optimization Techniques | | | | | | | |
| 24-479-0105: Advanced Natural Language Processing | | | | | | | |
| 24-479-0106: Digital Image and Video Processing | | | | | | | |
| 24-479-0107: Mathematics for Machine Learning | | | | | | | |
| 24-479-0108: Algorithmic Game Theory | | | | | | | |
| 24-479-0109: Data Engineering, Analytics and Visualization | | | | | | | |
| 24-479-0110: Algorithms for Modern Data Models | | | | | | | |
| Semester - II | | | | | | | |
| 1 | 24-479-0201 | Reinforcement Learning | C | 4 | 4 | 2 | 100 |
| 2 | 24-479-0202 | Applied Data Science | C | 4 | 4 | 2 | 100 |
| 3 | 24-479-0203 | Deep Learning | C | 4 | 4 | 2 | 100 |
| 4 | 24-479-0204 | Seminar | C | 1 | 0 | 3 | 100 |
| 5 | - | Elective III | E | 3 | 4 | 2 | 100 |
| 6 | - | Elective IV | E | 3 | 4 | 2 | 100 |
| Total for Semester II | | | | 19 | 20 | 13 | 600 |
| Electives | | | | | | | |
| 24-479-0205: Probabilistic Graphical Models | | | | | | | |
| 24-479-0206: Bioinformatics | | | | | | | |
| 24-479-0207: Large Language Models | | | | | | | |
| 24-479-0208: Programming Massively Parallel Processors | | | | | | | |
| 24-479-0209: Modelling Cyber Physical Systems | | | | | | | |
| 24-479-0210: Foundations of Federated Learning | | | | | | | |
| 24-479-0211: Image and Video Coding | | | | | | | |
| 24-479-0212: Natural Language Processing with Deep Learning | | | | | | | |
| Semester - III | | | | | | | |
| 1 | 24-479-0301 | Elective – MOOC | E | 2 | 0 | 10 | 100 |
| 2 | 24-479-0302 | Internship * | C | 1 | 0 | 0 | 100 |
| 3 | 24-479-0303 | Dissertation & Viva Voce | C | 15 | 0 | 20 | 100 |
| Total for Semester III | | | | 18 | 0 | 30 | 300 |
| Semester - IV | | | | | | | |
| 1 | 24-479-0401 | Dissertation & Viva Voce | C | 17 | 0 | 30 | 100 |
| Total credits for Degree : 72 | | | | Total Mark: 1500 | | | |
| *The students should complete the Course 24-479-0302 : Internship during the Vacation period (May-June) | | | | | | | |

24-479-0101: Mathematics for Computing

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

This course introduces the study of mathematical structures that are fundamentally discrete in nature. The course is intended to cover the main aspects which are useful in studying, describing and modeling of objects and problems in the context of Linear Algebra, computer algorithms and programming languages.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Analyse the different methods for proving the correctness of the theorems and problems. | Analyse |
| CO2 | Understand and apply the basic concepts of Linear Algebra. | Apply |
| CO3 | Understand and apply the basic aspects of Descriptive statistics. | Apply |
| CO4 | Understand and apply the fundamentals of probability theory. | Apply |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | 2 | - | - | 3 | - | - | - |
| CO3 | 3 | 2 | - | - | 3 | - | - | - |
| CO4 | 3 | 1 | - | - | 3 | - | - | - |

Course Content

1. Introduction – proofs – propositions – predicates and quantifiers – truth tables – first order logic – satisfiability – pattern of proof – proofs by cases – proof of an implication – proof by contradiction – proving iff – sets – proving set equations – Russell’s paradox – well-ordering principle – induction – invariants – strong induction – structural induction
2. Vectors-Coordinate system-vector addition-vector multiplication-Linear combinations, span, and basis vectors-Matrix multiplication as composition-Three-dimensional linear transformations-The determinant-Inverse matrices, column space and null space- Nonsquare matrices as transformations between dimensions-Dot products and duality-Cross products-Cross products in the light of linear transformations-Cramer's rule-Change of basis-Eigenvectors and eigenvalues-vector spaces
3. Descriptive statistics: histogram, sample mean and variance, order statistics, sample covariance, sample

covariance matrix – Frequentist statistics: sampling, mean square error, consistency, confidence intervals, parametric and non-parametric model estimation

4. Probability theory: probability spaces, conditional probability, independence – Random variables: discrete and continuous random variables, functions of random variables, generating random variables – Multivariate random variables: joint distributions, independence, generating multivariate random variables, rejection sampling – Expectation: Mean, variance and covariance, conditional expectation
5. Random process: definition, mean and autocovariance functions, iid sequences, Gaussian and Poisson process, random walk – Convergence of random process: types of convergence, law of large numbers, Central limit theorem, monte carlo simulation – Markov chains: recurrence, periodicity, convergence, markov-chain monte carlo- Gibbs sampling, EM algorithm, variational inference

References

1. Bronson, R., Costa, G.B., Saccoman, J.T. and Gross, D., Linear algebra: algorithms, applications, and techniques. 4e, 2023.
2. Eric Lehman, F Thomson Leighton, Albert R Meyer, Mathematics for Computer Science, 1e, MIT, 2010.
3. Susanna S. Epp, Discrete Mathematics with Applications, 4e, Brooks Cole, 2010.
4. Gary Chartrand, Ping Zhang, A First Course in Graph Theory, 1e, Dover Publications, 2012. in
5. John Tsitsiklis. 6.041SC Probabilistic Systems Analysis and Applied Probability. Fall 2013. Massachusetts Institute of Technology: MIT OpenCourseWare. <https://ocw.mit.edu>
6. Albert Meyer. 6.844 Computability Theory of and with Scheme. Spring 2003. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>.
7. Michael Mitzenmacher and Eli Upfal; Probability and Computing, 2ed, Cambridge University Press, 2017

Online Resources: Course notes of Carlos Fernandez-Granda, DS-GA 1002: Probability and Statistics for Data Science https://cims.nyu.edu/~cfgranda/pages/DSGA1002_fall17/index.html

24-479-0102: Artificial Intelligence and Machine Learning

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

Machine learning is programming computers to optimize a performance criterion using example data or past experience. This course is to discuss many methods that have their bases in different fields: statistics, pattern recognition, neural networks, artificial intelligence, signal processing, control, and data mining. Major focus of the course is on the algorithms of machine learning to help students to get a handle on the ideas, and to master the relevant mathematics and statistics as well as the necessary programming and experimentation.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|--|------------------|
| CO1 | Understand and explain the different types of the learning process, and key ethical considerations. | Understand |
| CO2 | Learn to effectively prepare data for machine learning models through data cleaning, feature selection, and dimensionality reduction. | Apply |
| CO3 | Implement and interpret linear and non-linear regression models, while comparing various classification techniques including tree-based, kernel, and ensemble methods. | Apply |
| CO4 | Gain practical knowledge in identifying data clusters using various algorithms and discovering hidden patterns through association rule learning. | Analyze |
| CO5 | Understand the basic building blocks of neural networks, implement the backpropagation algorithm, and explore the concept of MDPs and Q-learning. | Apply |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | - | 3 | 3 | 2 | - |
| CO3 | 3 | - | - | 2 | 3 | 3 | 2 | - |
| CO4 | 3 | - | - | 2 | 3 | 3 | 2 | - |
| CO5 | 3 | - | - | 2 | 3 | 3 | 2 | - |

Course Content

1. Introduction to AI - What is AI? A Brief History of AI - Different types of AI - Applications of AI - Problem Solving Methods – Heuristics. Knowledge Representation and Reasoning - Planning and Decision-Making: Ethics and Societal Impact of AI.
2. Machine Learning Fundamentals - Concept of Machine Learning: Definition, applications, types of learning (supervised, unsupervised, reinforcement) - Hypothesis Spaces and Inductive Bias - Learning Process- Machine Learning Ethics and Bias. Data Preprocessing and Feature Engineering: Data Representation - Data Preprocessing - Features and Types - Dimensionality Reduction – Feature Identification - Feature selection – Feature extraction - Feature Importance-High dimensional data and Manifolds.
3. Regression and Classification - Regression: Linear Regression – Non-Linear regression – evaluation metrics for regression– Classification: Binary, multi-class, and multi-label classification – lazy learners - tree-based techniques - kernel-based techniques - probabilistic techniques - and ensembled techniques – evaluation metrics for classification.
4. Clustering and Rule Mining - Clustering: Partitioning based – hierarchical based – density based– grid-based – model based - Rule mining: Apriori algorithm, FB Growth - association rules. Outlier Detection - LOF.
5. Artificial Neural Networks and Reinforcement Learning -Neural Networks: McCulloch-Pitts neurons, Hebb’s networks, Hopfield networks, Boltzmann machines, Perceptrons, multilayer perceptrons, backpropagation. Reinforcement Learning: Markov Decision Processes (MDPs), Q-learning.

References

1. Ethem Alpaydin, Introduction to Machine Learning, 3e, MIT Press, 2014
2. Tom M. Mitchell, Machine Learning, McGraw Hill Education; 1e, 2017
3. Stephen Marsland, Machine Learning, An Algorithmic Perspective, 2e, CRC Press, 2015
4. Giuseppe Bonaccorso, Machine Learning Algorithms, 1e, Packt Publishing Limited, 2017
5. Ethem Alpaydin, Machine Learning- The New AI, MIT Press, 1e, 2016
6. Andrew Ng, Machine Learning Yearning, ATG AI (Draft version), 1e, 2018
7. Rohit Singh, Tommi Jaakkola, and Ali Mohammad.6.867 *Machine Learning*. Fall 2006. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>
8. Andrew Ng, <https://www.coursera.org/learn/machine-learning>

24-479-0103: Design and Analysis of Algorithms

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description:

The course covers the foundational algorithms in depth. The course helps in understanding the working and complexity of the fundamental algorithms and to develop the ability to design algorithms to attack new problems.

Course Outcomes (CO)

| CO | Course Outcome Statement | Cognitive Levels |
|-----|---|------------------|
| CO1 | Understand the basic concepts of design and analysis of fundamental algorithms. | Understand |
| CO2 | Develop the ability to design algorithms to attack new problems. | Apply |
| CO3 | Prove the correctness of algorithms. | Analyze |
| CO4 | Develop the ability to analyze the complexity of algorithms. | Analyze |
| CO5 | Understand Complexity classes, concepts of P and NP problems | Understand |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | 2 | 3 | 3 | - | - |
| CO3 | - | 1 | - | 2 | 3 | 3 | - | - |
| CO4 | 3 | 1 | - | - | 3 | 3 | - | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | - | - |

Course Content

1. Introduction to design and analysis of algorithms, models of computation, correctness proofs, insertion sort, computational complexity, Master theorem , proof of Master theorem, merge sort, heaps, heap sort, binary search, binary search trees.
2. Graph algorithms, BFS and DFS, Dijkstra's algorithm, proof of correctness of Dijkstra's algorithm, Complexity analysis of Dijkstra's algorithm , Negative weight edges and cycles , Bellman-Ford algorithm, proof of correctness and complexity of Bellman-Ford, All pairs shortest paths, Floyd-Warshall algorithm, proof of correctness and complexity, Minimum Spanning Trees , Prim's algorithm, Cut property, Kruskal's algorithm, proof of correctness and complexity analysis of Kruskal's Algorithm, Maximum-Flow networks, Ford-Fulkerson method, proof of correctness and complexity, Edmonds-Karp algorithm
3. Probability review, Experiments, outcomes, events, Random variables, Expectation, Linearity of

- Expectation, Indicator Random Variables, Hiring Problem, Quicksort , Best case and Worst case complexity, Randomized Quicksort , Average case complexity , Hashing, Chaining, Open Addressing, Universal Hashing, Perfect Hashing , Analysis of hashing operations
4. Dynamic Programming , Rod-cutting problem, Recursive formulation, Bottom-up reformulation of recursive algorithms, Optimal Substructure Property, Matrix chain multiplication, Complexity of dynamic programming algorithms, Sequence Alignment , Longest common subsequence, Greedy algorithms, Optimal substructure and greedy-choice properties , 0-1 and fractional Knapsack problems, Huffman coding
 5. P vs NP, NP Hardness, Reductions, Travelling Salesman Problem, NP-Completeness, SAT, 2- SAT and 3-SAT, Vertex Cover

References

1. Michale T Goodrich and Roberto Tamassia, Algorithm Design and Applications, Wiley, 2014
2. Thomas H. Cormen et al, Introduction to Algorithms, MIT Press; 4th edition 2022.
3. Jon Kleinberg, Eva Tardos, Algorithm Design, Pearson; 1st edition August 2013.
4. Robert Sedgewick, Kevin Wayne, Algorithms, Addison Wesley; 4th edition 2011.
5. Steven S. Skiena, The Algorithm Design Manual, Springer; 3rd ed. October 2020

24-479-0104: Advanced Optimization Techniques

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

Virtualization provides the benefit of reducing the total cost of ownership and improving the business agility. This course systematically introduces the concepts and techniques used to implement the major components of virtual servers behind the scene. It discusses the details on hypervisor, CPU scheduling, memory management, virtual I/O devices, mobility, and etc.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|---|------------------|
| CO1 | Understand the basic concepts of optimization and its applications. | Understand |
| CO2 | Understand the mathematical representation and classical methods for solving optimization problems. | Understand |
| CO3 | Explain and demonstrate working principles of various population based optimization techniques. | Apply |
| CO4 | Applied understanding of current approaches for practical problem solving. | Apply |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | 3 | - | - |
| CO2 | 3 | - | - | - | 3 | 3 | - | - |
| CO3 | 3 | 1 | - | - | 3 | 3 | - | - |
| CO4 | 3 | 1 | - | 2 | 3 | 3 | 2 | - |

Course Content

1. Introduction to optimization- formulation of optimization problems-Review of classical methods- Linear programming-Nonlinear programming-Constraint optimality criteria-constrained optimization- Population based optimization techniques
2. Genetic Algorithm-Introduction-Working principle-Representation-selection-fitness assignment-reproduction-cross over-mutation-constraint handling-advanced genetic algorithms- Applications-Simulated Annealing-Selecting the parameters-Sufficiently near neighbour-Transition probabilities-Barrier avoidance
3. Differential Evolution-Introduction-Working principles-parameter selection-advanced algorithms in

Differential evolution-Biogeography-Based Optimization-Introduction-Working Principles- Algorithmic variations

4. Particle Swarm Optimization-Introduction- Working principles- Parameter selection- Neighborhoods and Topologies-Convergence-Artificial Bee Colony Algorithm-Introduction- Working principles- Applications-Cuckoo search based algorithm-Introduction- Working principles- Random walks and the step size-Modified cuckoo search
5. Hybrid Algorithms-Concepts- divide and conquer- decrease and conquer-HPABC-HBABC- HDABC-HGABC-Shuffled Frog Leaping Algorithm-- Working principles -Parameters- Grenade Explosion Algorithm-Working principle-Applications

References

1. Dan Simon, Evolutionary Optimization Algorithms, 1e, Wiley, 2013
2. Martins, Joaquim RRA, and Andrew Ning. Engineering design optimization. 1e, Cambridge University Press, 2021.
3. Rao, Singiresu S. Engineering optimization: theory and practice. 5e, John Wiley & Sons, 2019.

24-479-0105: Advanced Natural Language Processing

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description:

Natural Language Processing (NLP) is a crucial technology in today's information age, with widespread applications across various sectors due to the centrality of language in human communication. In recent years, deep learning approaches, utilizing neural networks, have achieved remarkable success in numerous NLP tasks. These methods eliminate the need for traditional, task-specific feature engineering by employing end-to-end neural models. This course provides students with a comprehensive overview of the latest advancements in Natural Language Processing.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|---|------------------|
| CO1 | Understand the fundamentals of NLP and apply it to do basic text processing. | Apply |
| CO2 | Utilize word vectors like TF-IDF, PMI and word embeddings effectively in NLP tasks. | Apply |
| CO3 | Apply various parsing techniques on English text, and evaluate their performance. | Analyze |
| CO4 | Apply advanced architectures such as RNNs, LSTMs, and encoder-decoder models with attention for sequence modelling. | Apply |
| CO5 | Apply NLP techniques in machine translation, question answering, and information retrieval. | Apply |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | 1 | - | 2 | 3 | 3 | 2 | - |
| CO2 | 3 | 1 | 1 | 2 | 3 | 3 | 2 | - |
| CO3 | 3 | 1 | 1 | 2 | 3 | 3 | 2 | - |
| CO4 | 3 | 1 | 1 | 3 | 3 | 3 | 2 | - |
| CO5 | 3 | 1 | 1 | 1 | 3 | 3 | 2 | - |

Course Content

1. Introduction to Natural Language Processing - Various stages of traditional NLP – Challenges - Basic Text

Processing techniques - Common NLP Tasks. N-gram Language Models - Naive Bayes for Text Classification, and Sentiment Analysis - Introduction to Neural Networks.

2. Word representations - Lexical Semantics, Vector Semantics, TF-IDF, Pointwise Mutual Information (PMI), Neural Word embeddings - Word2vec, GloVe. Contextual Word Embeddings. Evaluating Vector Models - Feedforward neural networks for text Classification
3. Linguistic Structures - Constituency Trees, Context-Free Grammars, Ambiguity, CKY Parsing, Dependency Parsing - Transition-Based Dependency Parsing, Graph-Based Dependency Parsing, Evaluation.
4. Sequence Modelling - Recurrent Neural Networks, RNNs as Language Models, RNNs for NLP tasks, Stacked and Bidirectional RNN architectures, Recursive Neural Networks, LSTM & GRU, Common RNN NLP Architectures, Encoder-Decoder Model with RNNs, Attention models.
5. NLP Applications - Machine Translation, Question Answering and Information Retrieval, Research perspectives in NLP, Introduction to Large Language Models

References

1. Dan Jurafsky and James H. Martin. Speech and Language Processing (2024 pre-release)
2. Jacob Eisenstein. Natural Language Processing
3. Yoav Goldberg. A Primer on Neural Network Models for Natural Language Processing
4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning
5. Delip Rao and Brian McMahan. Natural Language Processing with PyTorch.
6. Lewis Tunstall, Leandro von Werra, and Thomas Wolf. Natural Language Processing with Transformers

24-479-0106: Digital Image and Video Processing

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

The aim of this course is to inculcate a comprehensive knowledge about various Digital Image and Video Processing techniques. The objectives are to give an in-depth knowledge about the basic theory and algorithms related to Digital Image and Video Processing, provide awareness about the current technologies and issues, provide hands-on experience in using computers to process digital images and Videos using Python and OpenCV library.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|--|------------------|
| CO1 | Understand the fundamental concepts of signal and image processing systems. | Understand |
| CO2 | Evaluate the different spatial and frequency domain filters for image enhancement and restoration. | Analyze |
| CO3 | Understand the color image fundamentals and apply the different filters on color images. | Apply |
| CO4 | Analyze different image segmentation algorithms. | Analyze |
| CO5 | Understand the different motion estimation and depth perception techniques. | Understand |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | 2 | 2 | - |
| CO2 | 3 | - | - | 2 | 3 | 2 | 2 | - |
| CO3 | 3 | - | - | 2 | 3 | 2 | 2 | - |
| CO4 | 3 | - | - | 2 | 3 | 2 | 2 | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | 2 | - |

Course Content

1. Signals: Impulse Sequence - Exponential Sequence - Periodic Sequence. Linear Systems - Shift- Invariant systems - Linear Shift Invariant (LSI) systems – Convolution - Correlation. Image Transforms: Fourier Transform - Discrete Fourier Transform - Z- transform – KL Transform. Causal Systems - Random Signals - Stationary Process - Markov Process.
2. Intensity Transformation and Spatial Filtering: Intensity Transformation Functions. Histogram Processing: Histogram Equalization - Histogram Matching. Image enhancement: Arithmetic/Logic operations - Image

- Subtraction - Image Averaging. Spatial Filtering: Smoothing Spatial Filters - Sharpening Spatial Filters - Laplacian Filter - Unsharp masking - High Boost Filter. Gradient operators: Edge detection filters. Frequency Domain Smoothing - Frequency Domain Sharpening Filters - Laplacian in Frequency domain - Homomorphic Filtering.
3. Image degradation/Restoration process model - Noise probability density functions - Spatial Filtering: Mean Filters - Order-statistics filter - Adaptive Filters - Periodic Noise Reduction –Band-reject filters - Band-pass filters - Notch filters. Inverse filtering - Wiener filtering - Performance measures. Color image processing: Color fundamentals - Color models – RGB, CMYK – HIS - Color image smoothing and sharpening – Color image histogram - Color edge detection.
 4. Point and line detection - Hough Transform. Image Segmentation: Fundamentals – Thresholding – Otsu’s optimum global thresholding - Region-based segmentation: Region growing - Region Splitting and Merging - Segmentation using Morphological Watersheds.
 5. Color video processing: Video display - Composite versus component video - Progressive and interlaced scan. Motion estimation: Optical flow - pixel based motion estimation - block matching algorithm - deformable block matching algorithm - Global and region based motion estimation - multiresolution motion estimation - Feature based motion estimation. Stereo and multi-view sequence processing: Depth perception - Stereo imaging principle - Disparity estimation.

References

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 4th Ed., Pearson, March 2017.
2. Anil K. Jain, "Fundamentals of Digital Image Processing", Pearson, 1st Ed., 1988.
3. William K. Pratt, "Digital Image Processing: PIKS Scientific Inside", John Wiley & Sons, 4th Ed., 2007.
4. Azriel Rosenfeld, Avinash C. Kak, "Digital Picture Processing", Morgan Kaufmann, 2nd Ed., 1982.
5. Bernd Jahne, "Digital Image Processing", Springer, 6th Ed., 2005.
6. Yao Wang, Jorn Ostermann, Ya-Qin Zhang, "Video Processing and Communications", Pearson, 1st Ed., 2001.
7. Alan C. Bovik, "The Essential Guide to Video Processing", Academic Press, 2nd Ed., 2009
8. A. Murat Tekalp, "Digital Video Processing", Prentice Hall, 2nd Ed., 2015.

24-479-0107: Mathematics for Machine Learning

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

The aim of this course is to inculcate a comprehensive knowledge about mathematical formalisms required to understand machine learning concepts. The course introduces in detail linear algebra, probability concepts, optimization, and some of the applications

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|--|------------------|
| CO1 | Outline the fundamental concepts of linear algebra. | Understand |
| CO2 | Illustrate matrix diagonalization. | Apply |
| CO3 | Analyze the process of backpropagation. | Analyze |
| CO4 | Apply Bayes theorem. | Apply |
| CO5 | Analyze the gradient descent algorithm | Analyze |
| CO6 | Examine linear programming problems. | Analyze |
| CO7 | Build some of the basic machine learning applications. | Apply |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | 2 | - | - |
| CO2 | 3 | - | - | - | 3 | 2 | - | - |
| CO3 | 3 | - | - | - | 3 | 2 | - | - |
| CO4 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO6 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO7 | 3 | - | - | 2 | 3 | 2 | - | - |

Course Contents:

1. Linear Algebra – vectors – matrices – systems of linear equations – vector spaces – linear independence – basis and rank – linear mappings – affine spaces – Norms – lengths and distances – angles and orthogonality– orthonormal basis – inner product of functions– orthogonal projections – rotations

2. Determinant and trace – eigenvalues and eigenvectors – cholesky decomposition – eigendecomposition and diagonalization – singular value decomposition – matrix approximation – Partial differentiation – gradients – gradients of vectors and matrices – higher order derivatives – backpropagation and automatic differentiation – multivariate Taylor series
3. Probability review – conditioning and independence – Bayes theorem – counting – discrete and continuous random variables – discrete and continuous probability distributions – Gaussian distribution – Bayesian inference – limit theorems – estimation – conjugacy and exponential family – inverse transform – sampling from distributions
4. Optimization – gradient descent – choosing the right step size – gradient descent with momentum – stochastic gradient descent – constrained optimization and Lagrange multipliers – convex optimization – linear programming – quadratic programming – Empirical risk minimization – probabilistic modeling and inference – directed graphical models
5. Applications: linear regression – parameter estimation – Bayesian Linear Regression – PCA – Maximum Variance Projections – Low-Rank Approximations – Gaussian mixture models – Parameter learning via maximum likelihood – EM Algorithm – Support Vector Machines – Separating Hyperplanes – Primal and Dual forms – The Kernel Trick

References:

1. Gilbert Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019
2. Marc Peter Deisenroth et al., Mathematics for Machine Learning, 1e, Cambridge Press, 2020, Ebook: <https://mml-book.com>
3. Mehryar Mohri et al., Foundations of Machine Learning, 2nd Edition, The MIT Press, 2018
4. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016
5. James Stewart, Multivariable Calculus, 7th Edition, Cengage Learning, 2011
6. Dimitri P. Bertsekas, John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, 2008.
7. Morris H. DeGroot, Mark J. Schervish, Probability and Statistics, 4th Edition, Pearson, 2011

24-479-0108: Algorithmic Game Theory

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

Game theory is a branch of mathematics and economics which models interactions of agents as games. Algorithmic game theory is the intersection of game theory and computer science. This course introduces algorithmic game theory in an application-oriented manner.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Explain the fundamental concepts of non-cooperative and cooperative game theory | Understand |
| CO2 | Distinguish between standard game models and solution concepts. | Analyze |
| CO3 | Illustrate a variety of advanced algorithmic techniques and complexity results for computing game theoretical solution concepts | Analyze |
| CO4 | Identify rationale of decision making in games. | Understand |
| CO5 | Apply solution concepts, algorithms, and complexity results to unseen games that are variants of known examples. | Apply |
| CO6 | Compare the state of the art in some areas of algorithmic research, including new developments and open problems | Evaluate |

Mapping with Program Outcomes

| CO | PO1 | PO 2 | PO 3 | PO 4 | PSO 1 | PSO 2 | PSO 3 | PSO 4 |
|-----|-----|------|------|------|-------|-------|-------|-------|
| CO1 | 3 | - | - | - | 3 | 2 | - | - |
| CO2 | 3 | - | - | - | 3 | 2 | - | - |
| CO3 | 3 | - | - | - | 3 | 2 | - | - |
| CO4 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO6 | 3 | - | - | - | 3 | 2 | - | 1 |

Course Content:

1. Introduction to game theory – strategies, costs, payoffs – solution concepts – finding equilibria – games with sequential moves – games with simultaneous moves – discrete strategies, continuous strategies – mixed strategies – games with incomplete information – expected payoffs – Prisoner’s dilemma and

- repeated games – Nash equilibrium – Computational complexity of Nash equilibrium
2. Games on networks – congestion games – selfish routing – Nash and wardrop equilibria for networks – price of anarchy – pricing network edges – network design with selfish agents – economic aspects of internet routing
 3. Epistemic game theory – Modeling knowledge – rationality and belief – common belief in rationality – game strategies and perfect recall – cryptography and game theory – modeling cryptographic algorithms as games – multi-party computations – MPC and games
 4. Mechanism design – general principles – social choice – incentives – algorithms mechanism design – distributed aspects – cost-sharing mechanisms – mechanism design without money – house allocation problem – stable matchings
 5. Voting – evaluation of voting systems – strategic manipulation of votes – auctions – types of auctions – winner’s curse – bidding strategies – fairness in auctions

References

1. Avinash K. Dixit et al., Games of Strategy, 4e, W. W. Norton & Company, 2014
2. Noam Nisan et al., Algorithmic Game Theory, 1e, Cambridge University Press, 2007
3. Steven Tadelis, Game Theory: An Introduction, 1e, Princeton University Press, 2013.
4. Michael Maschler, et al., Game Theory, 1e, Cambridge University Press, 2013.
5. Andres Perea, Epistemic Game Theory: Reasoning and Choice, 1e, Cambridge University Press, 2012

24-479-0109: Data Engineering, Analytics and Visualization

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

This course offers an integrated approach to understanding the lifecycle of data within modern organizations. It explores the foundational concepts, techniques, and tools necessary to engineer, analyze, and visualize data effectively for informed decision-making. Students will gain practical skills in data engineering, data analytics, and data visualization through hands-on projects and case studies.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the Fundamentals of Data Engineering | Understand |
| CO2 | Describe the life cycle phases of Data Analytics through discovery, planning and building. | Understand |
| CO3 | Understand and apply Data Analysis Techniques. | Apply |
| CO4 | Implement various Data streams. | Apply |
| CO5 | Understand item sets, Clustering, frame works & Visualizations. | Understand |
| CO6 | Understand the Data Visualizations | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 2 | - | - |
| CO2 | 3 | - | - | - | 3 | 2 | - | - |
| CO3 | 3 | - | - | - | 3 | 2 | - | - |
| CO4 | 3 | - | - | 2 | 3 | 1 | - | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO6 | 3 | - | - | - | 3 | 2 | - | - |

Course Content:

1. Introduction to Data Engineering: Overview of Data Engineering: Role, importance, and challenges, Data Lifecycle: Ingestion, storage, processing, analysis, and visualization. Data Storage Technologies: Relational Databases, NoSQL Databases, Data Warehouses, Distributed File Systems.
2. Data Processing Technologies: Batch Processing: MapReduce, Apache Spark, Stream Processing: Apache

Kafka, Apache Flink, Data Integration and ETL: Data Transformation: Data cleaning, enrichment, aggregation, and denormalization.

3. Introduction to Data Analytics: Sources and nature of data, classification of data (structured, semi-structured, unstructured), characteristics of data, introduction to Big Data platform, need of data analytics, analysis vs reporting, modern data analytic tools, applications of data analytics. Data Analytics Lifecycle: Need, key roles for successful analytic projects, various phases of data analytics lifecycle – discovery, data preparation, model planning, model building, communicating results, operationalization.
4. Data Analysis: Regression modeling, multivariate analysis, Bayesian modeling, inference and Bayesian networks, support vector and kernel methods, analysis of time series: linear systems analysis & nonlinear dynamics, rule induction, neural networks: learning and generalisation, competitive learning.
5. Introduction to Visualization and Stages – Computational Support – Issues – Different Types of Tasks – Data representation – Limitation: Display Space- Rendering Time – Navigation Links

References

1. Mobasher et al. "Data Engineering: Mining, Information, and Intelligence" Springer, 2010
2. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer
3. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press
4. Bill Franks, Taming the Big Data Tidal wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & Sons.
5. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley
6. Jiawei Han, Micheline Kamber "Data Mining Concepts and Techniques", Second Edition, Elsevier Robert Spence, "Information Visualization Design for Interaction", Second Edition, Pearson Education, 2006.
7. Paul Zikopoulos, Chris Eaton, Paul Zikopoulos, "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGraw Hill
8. Anil Maheshwari, "Data Analytics", McGraw Hill Education

24-479-0110: Algorithms for Modern Data Models

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description:

There exist both algorithmic and statistical challenges in modern large-scale applications and data analysis. This course describes the randomization and probabilistic techniques for modern computer science, with applications ranging from combinatorial optimization and machine learning to communication networks. The course covers the core material to advanced concepts. Also the emphasis is on methods useful in practice.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Relate the advanced concepts of probability theory and modern applications. | Analyze |
| CO2 | Explain the uncertainty in prediction due to intervention of random variables. | Analyze |
| CO3 | Examine graph models and their algorithms | Analyze |
| CO4 | Analyze evolutionary algorithms. | Analyze |
| CO5 | Interpret algorithms for evolving data streams | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO2 | 3 | - | - | 2 | 3 | - | - | - |
| CO3 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO4 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO5 | 3 | - | - | 2 | 3 | 1 | - | - |

Course Content:

1. Probability: Expectations - Tail Bounds - Chernoff Bound – Balls and Bins – Probabilistic Method – Markov chains and Random walks
2. Entropy, Randomness, and Information: Measure of randomness – Monte Carlo Method – Markov Chain Monte Carlo Method
3. Graph models and algorithms– Random graph Models- Algorithms for graph generation - Random graphs as models of networks, Power laws, Small world Phenomena
4. Components of evolutionary algorithms – Example applications – Genetic algorithms – Evolution strategies – Evolutionary programming

5. Sampling, sketching, data stream models, read-write streams, stream-sort, map-reduce - Algorithms in evolving data streams

References

1. Michael Mitzenmacher, Eli Upfal, Probability and Computing: Randomization and Probabilistic Techniques in Algorithms and Data Analysis, 2e, Cambridge University Press, 2017
2. Rajeev Motwani and PrabhakarRaghavan, Randomized Algorithms, Cambridge University Press; Reprint edition, 2010
3. S. Muthukrishnan, Data Streams: Algorithms and Applications, 1e, Now Publishers, 2005
4. Charu C. Aggarwal, Data Streams: Models and Algorithms, 1e, Springer, 2006
5. Agoston E. Eiben, J.E. Smith , Introduction to evolutionary computing, 1e, Springer, 2010

24-479-0201: Reinforcement Learning

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description

The course aims to introduce the concepts reinforcement learning and to impart an understanding of how reinforcement learning -- along with supervised and unsupervised learning -- form a building block of modern artificial intelligence. The course will provide a solid introduction to the field of reinforcement learning and students will learn about the core challenges and approaches, including generalization and exploration.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Define the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning | Analyze |
| CO2 | Demonstrate the ability to formulate a given problem as a reinforcement problem with all ingredients. | Apply |
| CO3 | Implement in code common RL algorithms | Apply |
| CO4 | Describe the exploration vs exploitation challenge | Understand |
| CO5 | Compare and contrast at least two approaches for addressing the above challenge. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 2 | - | - |
| CO2 | 3 | - | - | - | 3 | 2 | - | - |
| CO3 | 3 | - | - | 2 | 3 | 3 | - | - |
| CO4 | 3 | - | - | 2 | 3 | - | - | - |
| CO5 | 3 | - | - | 2 | 3 | - | - | - |

Course Content:

1. The Reinforcement Learning problem: evaluative feedback, non-associative learning, Rewards and returns, Markov Decision Processes, Value functions, optimality and approximation
2. Bandit Problems: Explore-exploit dilemma, Binary Bandits, Learning automata, exploration schemes
Dynamic programming: value iteration, policy iteration, asynchronous DP, generalized policy iteration
3. Monte-Carlo methods: policy evaluation, roll outs, on policy and off policy learning, importance sampling

Temporal Difference learning: TD prediction, Optimality of TD(0), SARSA, Q-learning, R- learning, Games and after states

4. Eligibility traces: n-step TD prediction, TD(λ), forward and backward views, Q(λ), SARSA(λ), replacing traces and accumulating traces.
5. Function Approximation: Value prediction, gradient descent methods, linear function approximation, Control algorithms, Fitted Iterative Methods Policy Gradient methods: nonassociative learning - REINFORCE algorithm, exact gradient methods, estimating gradients, approximate policy gradient algorithms, actor-critic methods Hierarchical RL: MAXQ framework, Options framework, HAM framework, Option discovery algorithms

References

1. R. S. Sutton and A. G. Barto; Reinforcement Learning - An Introduction. 2e, MIT Press (2018) eBook: <http://incompleteideas.net/book/the-book-2nd.html>
2. Marco Wiering and Martijn van Otterlo (Editors); Reinforcement Learning: State-of-the Art, Springer (2012)
3. Csaba Szepesvari; Algorithms for Reinforcement Learning, Morgan and Claypool Publishers (2010)
4. David Silver: <https://www.davidsilver.uk/teaching/>

24-479-0202: Applied Data Science

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description

This applied data science course empowers you to transform diverse data sets into valuable insights that solve real-world problems. Embark on a journey through the complete data science lifecycle, mastering each step from identifying questions to crafting impactful stories with your findings. Gain hands-on experience with cutting-edge techniques while developing the ethical compass to use data responsibly across various industries.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Navigate the Data Science Landscape: Grasp applications across industries, master the data science lifecycle. | Understand |
| CO2 | Master Data Preparation & Engineering: Implement warehousing concepts, build efficient data pipelines, ensure data quality. | Apply |
| CO3 | Analyze Data with Confidence: Utilize descriptive statistics, hypothesis testing, regression models, classification algorithms, and clustering techniques for insightful analysis. | Apply |
| CO4 | Craft Compelling Data Visualizations: Design effective visuals using best practices and popular tools, create impactful narratives to communicate findings. | Apply |
| CO5 | Embrace DataOps & Big Data Technologies: Understand DataOps automation, implement CI/CD practices, explore big data technologies like Hadoop, Spark, and Kafka, and analyze challenges and opportunities presented by big data. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 1 | - | - |
| CO2 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO3 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO4 | 3 | 1 | - | 2 | 3 | 2 | - | 1 |
| CO5 | 3 | 1 | - | 2 | 3 | 2 | - | - |

Course Content:

1. Introduction to Applied Data Science - Overview of the data science landscape and its applications in various industries- The data science lifecycle: problem identification, data collection, data cleaning and preprocessing, analysis, modeling, and communication.- Ethical considerations in data science.
2. Data Warehousing and Engineering - Introduction to data warehousing concepts: dimensional modeling, star schemas, snowflake schemas, data marts. Data warehousing technologies: relational databases, data warehouses, data lakes.Data engineering: data extraction, transformation, and loading (ETL) processes, data pipelines, data quality management.
3. Data Analytics - Descriptive statistics: measures of central tendency, measures of dispersion, measures of association.-Inferential statistics: hypothesis testing, confidence intervals.- Regression analysis: simple linear regression, multiple linear regression- Classification: decision trees, random forests, support vector machines.-Clustering: k-means clustering, hierarchical clustering.
4. Data Visualization - Principles of data visualization: selecting the right chart type, using color effectively, labeling charts clearly. Tools for data visualization: Tableau, Power BI, matplotlib, seaborn. Storytelling with data visualization: how to create visual narratives that communicate insights effectively.
5. DataOps and Big Data- Introduction to DataOps: automating the data pipeline, continuous integration and continuous deployment (CI/CD), monitoring and alerting- Big data technologies: Hadoop, Spark, Kafka.- Challenges and opportunities of big data.

References

1. Applied Data Science with Python and Jupyter: Use powerful industry-standard tools to unlock new, actionable insights from your data; Alex Galea (2018); Packt Publishing. ISBN: 9781789951929.
2. Applied Data Science - Lessons Learned for the Data-Driven Business; Braschler, Stadelmann, Stockinger (Eds.); Springer(2019).
3. <https://em360tech.com/sites/default/files/2020-08/DataOps%20Cookbook%202nd%20Edition%20FINAL.pdf>
4. Data Warehousing and Analytics: Fueling the Data Engine; David Taniar, Wenny Rahayu;Springer Cham(2022); <https://doi.org/10.1007/978-3-030-81979-8>

24-479-0203: Deep Learning

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description:

Deep learning is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. This course describes deep learning techniques used by practitioners in industry, including deep feedforward networks, regularization, optimization algorithms, convolutional networks, sequence modeling, and practical methodology. This course is useful to students planning careers in either industry or research, and for software engineers who want to begin using deep learning in their products or platforms

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the need for Deep learning, Feed forward networks, Learning XOR, Gradient based Learning, Hidden units. | Understand |
| CO2 | Differentiate between training error and generalization error, Underfitting and Overfitting. And Identify Regularization strategies, Dataset Augmentation, Adversarial Training. | Analyze |
| CO3 | Describe the working of Convolution Operation, Sparse interactions, Parameter sharing, Equivariant representations, Pooling and Recurrent Neural Networks | Understand |
| CO4 | Understand different types of Autoencoders, Undercomplete Autoencoders, Regularized Autoencoders, and Dimensionality Reduction. | Understand |
| CO5 | Explain deep generative models like Boltzmann Machines, Restricted Boltzmann Machines. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | 2 | 3 | - | - | - |
| CO3 | 3 | 1 | - | 2 | 3 | - | - | - |
| CO4 | 3 | - | - | 2 | 3 | - | - | - |
| CO5 | 3 | 1 | - | 2 | 3 | - | - | - |

Course Content:

1. Deep Networks: Feed forward networks – Learning XOR- Gradient based Learning – Hidden units –

Architecture design- Back propagation – Differentiation algorithms

2. Regularization for Deep Learning: Penalties-Constrained optimization-Under constrained problems- Dataset augmentation-Semi Supervised learning- Sparse representation- Adversarial training- Optimization for training deep models: Basic algorithms-Algorithms with adaptive learning rates
3. Convolutional Networks: Convolution-Pooling-Variants of pooling- Efficient convolutional algorithms – Recurrent and Recursive Nets: Recurrent Neural Networks-Deep Recurrent Networks- Recursive Neural Networks- Explicit memory
4. Linear Factor Models: Probabilistic PCA- ICA – Slow feature analysis – Sparse coding – Autoencoders: Undercomplete Autoencoders – Regularized Autoencoders- Learning Manifolds- Applications of Autoencoders – Representation learning
5. Deep generative models: Boltzmann Machines – RBM- Deep Belief Networks-Deep Boltzmann Machines- Convolutional Boltzmann Machines- Directed generative Nets

References

1. Nithin Buduma, Nikhil Buduma and Joe Papa, Fundamentals of Deep Learning, 2nd Edition, O'Reilly, 2022
2. Jon Krohn and Grant Beyleveld, Deep learning Illustrated, Addison-Wesley; 1st edition, 2019
3. M Gopal, Deep Learning, Pearson Education; 1st edition, 2022
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 1e, MIT Press, 2016
5. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, 1e, Shroff/O'Reilly, 2017

24-479-0204: Seminar

Core/Elective: **Core**

Semester: **2**

Credits: **1**

Course Description

The student has to prepare and deliver a presentation on a research topic suggested by the department before the peer students and staff. They also have to prepare a comprehensive report of the seminar presented.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Identify, read, and interpret an academic research article from the literature that is related to his/her academic area of interest and present it before the committee. | Analyze |
| CO2 | Organize and communicate technical and scientific findings effectively in written and oral forms. | Apply |
| CO3 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | 3 | - | 2 | 1 | - | - | 3 |
| CO2 | - | 3 | - | - | 1 | - | - | 3 |
| CO3 | 2 | 3 | - | 2 | 1 | - | - | 3 |

24-479-0205: Probabilistic Graphical Models

Core/Elective: **Elective**

Semester: 2

Credits: 3

Course Description

Probabilistic Graphical models (PGM) are a foundation for understanding many methods of artificial intelligence, machine learning and estimation. Machine learning provides algorithms for solving problems by using training data. This course will give insight into how to formulate problems so that machine learning can be used effectively. Building good models can help learn with less data by constraining the learning space. Bayesian models are at the heart of most estimation methods. Formulation of these models is the first step in developing an estimation algorithm. The estimation itself is in many cases just inference on the model given some evidence. Approximate inference techniques such as those covered in this course are important in solving many very hard estimation problems in science and engineering. Data scientists, machine learning enthusiasts, engineers, and those who curious about the latest advances in machine learning will find PGM interesting

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrate application of Probability and Graph Theory in reasoning. | Apply |
| CO2 | Discuss how different graphs represent both factorization and independent relations. | Analyze |
| CO3 | Utilize message passing algorithms for inference. | Apply |
| CO4 | Examine methods for learning uncertainties in a model's parameters. | Analyze |
| CO5 | Experiment with graph building tools. | Apply |
| CO6 | Apply Bayesian networks and Markov networks to many real world problems. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | - | 3 | - | - | - |
| CO3 | 3 | - | - | 2 | 3 | - | - | - |
| CO4 | 3 | - | - | 2 | 3 | - | - | - |
| CO5 | 3 | - | - | 2 | 3 | 2 | - | - |
| CO6 | 3 | - | - | 2 | 3 | 2 | - | - |

Course Content:

1. Probabilistic reasoning: Representing uncertainty with probabilities – Random variables and joint distributions – Independence – Querying a distribution - Graphs
2. Representation: Bayesian Network (BN) representation – Independencies in BN – Factorizing a distribution – D-separation- Algorithm for D-separation – From distributions to Graphs
3. Undirected Graphical Models: Factor products – Gibbs distribution and Markov networks – Markov network independencies – Factor graphs – Learning parameters – Conditional Random Fields
4. Gaussian Network Models: Multivariate Gaussians – Gaussian Bayesian networks – Gaussian Markov Random Fields – Exact Inference: variable elimination- Sum-product and belief updates – The Junction tree algorithm
5. Learning: Learning Graphical Models – Learning as optimization – Learning tasks – Parameter estimation – Structure learning in BN – Learning undirected models – Actions and decisions

References:

1. Daphne Koller, Nir Friedman, Probabilistic Graphical Models- Principles and Techniques, 1e, MIT Press, 2009
2. Richard E. Neapolitan, Learning Bayesian Networks, 1e, Pearson, 2019
3. Christian Borgelt, Rudolf Kruse and Matthias Steinbrecher, Graphical Models- Methods for data analysis and Mining, 2e, Wiley, 2009
4. David Bellot, Learning Probabilistic Graphical Models in R, Packt Publishing, 1e, 2016
5. Luis Enrique Sucar, Probabilistic Graphical Models, 1e, Springer Nature, 2015
6. Coursera: <https://www.coursera.org/specializations/probabilistic-graphical-models>

24-479-0206: Bioinformatics

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

Present fundamental concepts from molecular biology, computational problems in molecular biology and some efficient algorithms that have been proposed to solve them.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Understand and appreciate basic concepts of molecular Biology and Human genome project. | Understand |
| CO2 | Illustrate and explain various sequence alignment algorithms. | Apply |
| CO3 | Demonstrate and evaluate different algorithms for identifying optimal phylogenetic trees. | Analyze |
| CO4 | Understand the concepts of structure prediction in molecular biology. | Understand |
| CO5 | Understand and demonstrate an algorithm in the literature for the domain. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | 2 | 3 | - | - | - |
| CO3 | 3 | 1 | - | - | 3 | - | - | - |
| CO4 | 3 | - | - | 2 | 3 | - | - | - |
| CO5 | 3 | 1 | - | 2 | 3 | 2 | - | 2 |

Course Content

1. Bioinformatics introduction-Branches of bioinformatics-Basic concepts of molecular Biology-Proteins- Nucleic acids– genes and genetic synthesis – translation- transcription- protein Synthesis- Chromosomes- Maps and sequences- Biological databases
2. Sequence alignment-Concepts of alignment-Gap Penalty-Pairwise sequence alignment algorithms- Dot Matrix-Global & Local alignment-Multiple sequence alignment algorithms-Scoring matrices-PAM, BLOSUM-Heuristic Methods -BLAST-FASTA
3. Fragment Assembly of DNA - Biological Background-human genome project – Models - Algorithms - Heuristics - Physical Mapping of DNA - Internal Graph Models – Hybridization Mapping - Heuristics -

Genome rearrangements-Oriented Blocks- unoriented Blocks

4. Molecular Phylogeny-Phylogenetic Trees –Methods of phylogeny-Maximum Parsimony-Maximum Likelihood-Distance methods-Binary Character States- Perfect phylogeny
5. Molecular Structure Prediction- Secondary structure prediction-Protein Folding problems-Protein threading- Computing with DNA-Hamilton Path Problems-Computer aided Drug design- peptide drug-chemical drug

References

1. Rastogi, S. C., Parag Rastogi, and Namita Mendiratta. Bioinformatics: Methods and Applications- Genomics, Proteomics and Drug Discovery. PHI Learning Pvt. Ltd., 5e, 2022.
2. Neil James and Pavel A Pevzner, An introduction to Bioinformatics Algorithms, 4e, OUPress, 2014
3. Zhumur Ghosh, Bibekanand Mallick, Bioinformatics : Principles and Applications, OUPress, 2015
4. Concord Bessant, Darren Oakley, Ian Shadforth, Building Bioinformatics Solutions, OUPress, 2014
5. Peter Clote and Rolf Backofen, Computational Molecular Biology-An introduction, 1e, Wiley Series, 2000

24-479-0207: Large Language Models

Core/Elective: Elective

Semester: 1

Credits: 3

Course Description:

This course provides an in-depth exploration of large language models, focusing on their architecture, applications, ethical considerations, and implications in various fields. Students will gain hands-on experience utilizing and fine-tuning large language models for multiple tasks. The course will also address the societal impact of these models and encourage critical thinking about their responsible use.

Prerequisites:

This course requires a basic understanding of Deep learning (DL) and Natural Language Processing (NLP) concepts. Proficiency in Python programming and Deep Learning frameworks like Pytorch or Keras is necessary.

Course Objectives:

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Understand the architecture and functioning of Large Language Models (LLMs). | Understand |
| CO2 | Fine-tune pre-trained language models for various NLP tasks using Deep Learning tools | Apply |
| CO3 | Design and generate prompts for generative LLMs to solve real-world challenges. | Apply |
| CO4 | Critically assess the ethical implications and societal impact of using LLMs. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | 3 | - | - | - |
| CO2 | 3 | - | - | 3 | 2 | 3 | - | - |
| CO3 | 3 | - | - | 3 | - | 3 | 2 | - |
| CO4 | 3 | - | - | 3 | - | 2 | - | - |

Course Content:

1. *Large Language Models (LLM)* - Introduction, Evolution of LLM, Foundation models & Instruction-following LLM; Pre-training & Transfer learning; Solving Natural Language Processing (NLP) tasks using LLMs.
2. *Transformers* - Encoder-Decoder models, Attention Mechanism; *Architecture* - Self-attention, Multi-head attention, Layer Normalization, Positional encoding; Pre-training and fine-tuning of Transformer based models - Autoregressive models (BERT), Generative model (GPT) and Sequence to sequence model (T5).
3. *Tokenization techniques* - Word & Sub-word modeling, Viterbi algorithm, Wordpiece tokenizer, Sentencepiece tokenizer, Byte Pair Encoding (BPE); *Text Embeddings* - Searching, classification, Clustering; Similarity Between Words and Sentences; Semantic Search.
4. *Prompt Engineering* - Introduction to Generative AI, Prompt design, Types of Prompting; Controlling model output via parameters; Use Case Ideation, Creating Custom Generative Models, Chain-of-Thought Prompting, Prompt Attacks and Mitigation.
5. *Ethical and Societal Implications of LLMs* - Bias and Fairness, Privacy concerns, Ethical considerations, Misinformation, and Disinformation challenges, Mitigation strategies; *Case study*: Application of LLMs in various domains. *Mini Project* - Building applications from pre-trained LLMs for real-world scenarios.

References

1. Bommasani, Rishi, et al. "On the opportunities and risks of foundation models.", Center for Research on Foundation Models (CRFM), Stanford Institute for Human-Centered Artificial Intelligence (HAI), Stanford University.
2. Rogers, Anna, Olga Kovaleva, and Anna Rumshisky. "A primer in BERTology: What we know about how BERT works." *Transactions of the Association for Computational Linguistics* 8 (2021): 842-866.
3. Lin, Jimmy, et al. *Pretrained Transformers for Text Ranking: BERT and Beyond*. United States, Morgan & Claypool Publishers, 2021.
4. Pal, Ankit. "Promptify: Structured Output from LLMs." (2022) available at <https://github.com/prompts-lab/Promptify>

24-479-0208: Programming Massively Parallel Processors

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

It used to be the case that parallel computing was confined to giant supercomputers. But nowadays it is literally everywhere - even in the small mobile handsets that most of us carry around. This course introduces parallel computing with a strong emphasis on programming.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Illustrate the parallel programming paradigm | Understand |
| CO2 | Identify the benefits of GPU programming model. | Understand |
| CO3 | Examine the CUDA programming architecture | Understand |
| CO4 | Assess programs written for single-processor systems and convert them into efficient parallel programs | Analyze |
| CO5 | Develop basic parallel programs in CUDA. | Apply |
| CO6 | Apply parallel programming to real-world applications | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 1 | - | - |
| CO2 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO3 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO4 | 3 | - | -- | 3 | 3 | 2 | - | - |
| CO5 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO6 | 3 | - | - | 3 | - | 3 | - | 2 |

Correlation level: 1= low, 2 = medium, 3 = High, '-' = no correlation

Course Content:

1. Introduction - parallel computing - more speed or parallelism - languages and models - sequential vs parallel - concurrent, parallel, distributed - parallel hardware architecture - modifications to the von Neumann Model.
2. Evolution of GPU - GPGPU - introduction to data parallelism - CUDA program structure - vector addition kernel - device global memory and data transfer

3. CUDA thread organization - mapping threads to multi-dimensional data - assigning resources to blocks - synchronization and transparent scalability - thread scheduling and latency tolerance
4. Memory access efficiency - CUDA device memory types - performance considerations - global memory bandwidth - instruction mix and thread granularity -floating point considerations
- 5 Parallel programming patterns - convolution - prefix sum - sparse matrix and vector multiplication - application case studies - strategies for solving problems using parallel programming.

References

1. David B. Kirk, Wen-mei W Hwu, Programming Massively Parallel Processors, 2e, Morgan Kaufmann, 2012
2. Peter Pacheco, Introduction to Parallel Programming, 1e, Morgan Kaufmann, 2011
3. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, 1e, Morgan Kaufmann, 2012
4. Jason Sanders, Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, 1e, AW Professional, 2010

24-479-0209: Modeling Cyber Physical Systems

Core/Elective: Elective

Semester: 2

Credits: 3

Course Description

Cyber-Physical Systems (CPS) is a new frontier for computer systems that is transforming the way people interact with engineered systems. CPS applications include systems such as aircraft, automotive, medical devices, process control, and critical infrastructure. Unlike the traditional computer systems, the interplay between the cyber and the physical systems in CPS brings significant challenges in the modeling, design, analysis and verification of such systems. The complex, interdisciplinary nature of CPS requires a unique approach for the education of CPS. This course introduces Modeling formalism of Cyber-Physical Systems (CPS), Modeling of physical and cyber systems, and software synthesis from these modeling formalisms.

Course Objectives

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Categorize the essential modeling formalism of Cyber-Physical Systems (CPS). | Understand |
| CO2 | Analyze the functional behavior of CPS based on standard modeling formalism. | Analyze |
| CO3 | Improve specific software CPS using existing synthesis tools. | Apply |
| CO4 | Contrast CPS requirements based on operating system and hardware architecture constraints. | Analyze |
| CO5 | Analyze and verify the correctness of CPS implementations against system requirements and timing constraints. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 1 | - | - |
| CO2 | 3 | - | - | - | 3 | 2 | - | - |
| CO3 | 3 | - | - | 3 | 3 | 3 | - | - |
| CO4 | 3 | - | - | - | 3 | 2 | - | - |
| CO5 | 3 | - | - | 3 | 3 | 3 | - | - |

Course Content:

1. Introduction to Cyber Physical System: Cyber physical system: Definition Applications, Design Process for Cyber Physical System: Modeling, Design, And Analysis: Modelling continuous dynamics, Newtonian Mechanics, Actor models, Properties that actors and the systems: Causal Systems, Memoryless Systems, Linearity and Time Invariance, Stability. Feedback control
2. Modeling Discrete Systems :Discrete Systems ,State, Finite-State Machines: Transitions, The occurrence of reaction, Update functions, Determinacy and Receptiveness, Extended State Machines, Nondeterministic

Finite State Machines , Behaviors and Traces

3. Hybrid Systems: Actor Model for State Machines, Continuous Inputs, State Refinements, Classes of Hybrid Systems: Timed Automata, Higher-Order Dynamics, Supervisory control
4. Composition of State Machines: Concurrent Composition: Side-by-Side Synchronous Composition Side-by-Side Asynchronous Composition, Shared Variables, Cascade Composition, General Composition, Hierarchical state machines
5. Concurrent Models of Computation : Structure of Models, Synchronous-Reactive Models: Feedback Models, Well-Formed and ill-Formed Models, Constructing a Fixed Point, Dataflow Models of Computation: Dataflow Principles, Synchronous Dataflow ,Dynamic Dataflow, Structured Dataflow, Process Networks, Timed Models of Computation: Time-Triggered Models, Discrete Event Systems, Continuous-Time Systems

References:

1. Edward Ashford Lee, Sanjit Arunkumar Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, 2e, MIT Press, 2017
2. Rajeev Alur , Principles of Cyber-Physical Systems, 1e, MIT Press, 2015
3. Raj Rajkumar, Dionisio de Niz, Mark Klein, Cyber-Physical Systems, 1e, AW Professional, 2017
4. Peter Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber- Physical Systems, and the Internet of Things, 3e, Springer, 2017

Online courses: Coursera: <https://www.coursera.org/learn/cyber-physical-systems-1>

24-479-0210: Foundations of Federated Learning

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

The course introduces Federated Learning (FL), the privacy preserving version of distributed machine learning. It explains the need for and the different types of FL. Also the important techniques to realise it are discussed.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Realize the significance of privacy concerns in the present world. | Understand |
| CO2 | Differentiate between FL and distributed machine learning. | Analyze |
| CO3 | Apply privacy preserving techniques in data processing and in particular in machine learning. | Apply |
| CO4 | Recognize FL as a dominant research area and understand the current research questions. | Understand |
| CO5 | Apply FL techniques to existing machine learning applications | Apply |
| CO6 | Understand the communication and computation challenges associated with FL | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | - | 3 | - | - | - |
| CO3 | - | - | - | 3 | 3 | - | 3 | - |
| CO4 | 3 | - | - | - | 3 | - | - | 3 |
| CO5 | 3 | - | - | 3 | 3 | 3 | - | - |
| CO6 | - | - | - | 3 | 3 | - | - | - |

Course Content

1. Introduction: Motivation - Privacy and other issues, Legal aspects - Consumer Online Privacy Rights Act (USA), General Data Protection Regulation (EU) , Definition and Applications of FL, Cross device and Cross Silo models.
2. Background: Classification based on data partitioning: Horizontal, Vertical and Transfer FL, Research Works in FL, Open Source Projects. Privacy Preservation Techniques - Secure Multi-Party

Computation.

3. Horizontal FL: Definition, Architectures - The Client - Server architecture, The Peer to Peer architecture, Global Model Evaluation, The Federated Averaging Algorithm - Federated Optimization, The FedAvg Algorithm. Improvements - Communication Efficiency, Client Selection.
4. Vertical FL: Privacy Preservation Techniques - Homomorphic Encryption, Differential Privacy. Definition of Vertical FL, Architecture, An Algorithm of VFL - Secure Federated Linear Regression.
5. Federated Transfer Learning: Heterogeneous Federated Learning, Instance based transfer, Feature based transfer and Model based transfer. Security definition of a FTL system. An FTL Framework - Additively Homomorphic Encryption, The FTL Training Process, The FTL Prediction process

References

1. Liu, Yang., Chen, Tianjian., Yu, Han., Yang, Qiang., Cheng, Yong. *Federated Learning. United States: Morgan & Claypool Publishers, 2019.*
2. Kairouz, Peter, et al. "Advances and open problems in federated learning." *Foundations and Trends® in Machine Learning* 14.1–2 (2021): 1-210.
3. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679>
4. <https://www.congress.gov/bill/116th-congress/senate-bill/2968/text>

24-479-0211: Image and Video Coding

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

The aim of this course is to give a rigorous introduction into the fundamental concepts of data compression with strong emphasis on the mathematical techniques and its applications to image and video coding. The main objectives of the course are to understand how digital data can be compressed using either lossless or lossy techniques, to provide a strong mathematical background in the field of coding theory, to expose the students to the standard compression techniques used in various coding standards and to expose the students to the latest image and video coding standards.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the mathematical preliminaries of lossless compression techniques and analyze the different entropy coding techniques. | Analyze |
| CO2 | Analyze the different dictionary-based and context-based coding techniques. | Analyze |
| CO3 | Understand the mathematical preliminaries of lossy compression techniques and analyze the different quantization-based compression techniques. | Analyze |
| CO4 | Understand the different approaches for video compression. | Understand |
| CO5 | Understand the important image and video compression standards. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO2 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO3 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO4 | 3 | - | - | - | 3 | 2 | - | - |
| CO5 | 3 | - | - | - | 3 | 2 | - | - |

Course Content

1. Introduction: Compression Techniques - Modeling and Coding. Mathematical Preliminaries for Lossless Compression: Information Theory – Models - Coding: Uniquely decodable codes - Prefix codes - Kraft-McMillan Inequality. Huffman Coding: Minimum Variance Huffman Codes - Length of Huffman Codes -

Adaptive Huffman Coding - Golomb codes - Rice codes - Tunstall codes. Arithmetic Coding: Integer Arithmetic Coding.

2. Dictionary Techniques: Static Dictionary - Digram coding - Adaptive Dictionary - LZ77 - LZ78 - LZW. Context-based Compression: Prediction with partial match - Burrows-Wheeler Transform – CALIC - Run-Length Coding – JBIG – JBIG2.
3. Mathematical Preliminaries for Lossy Coding: Distortion Criteria - Rate Distortion Theory. Scalar Quantization: Quantization problem - Uniform Quantizer - Lloyd-Max Quantizer - Adaptive Quantization - Non-uniform Quantization - Entropy-Coded Quantization. Vector Quantization: LBG Algorithm - Tree Structured and Structured Vector Quantizers. Differential Coding: Basic algorithm – DPCM. Transform Coding.
4. Content dependent video coding: Temporal prediction and Transform coding - Two dimensional shape coding - Joint shape and texture coding - Region based and object based video coding - Knowledge based video coding - Semantic video coding - Layered coding system - Scalable video coding.
5. Image Compression Standards: JPEG - JPEG 2000 - JPEG XR - JPEG-LS - JPEG XT - JPEG Pleno. Video Compression Standards: MPEG-4 - H.263 - H.264/AVC - H.265/HEVC - AVS China - Dirac.

References

1. Khalid Sayood, “Introduction to Data Compression”, Morgan Kaufmann Publishers, 4th Ed., 2012.
2. David Salomon, “Data Compression – The Complete Reference”, Springer, 4th Ed., 2006.
3. Alistair Moffat, Andrew Turpin, “Compression and Coding Algorithms”, Kluwer Academic Publishers, 1st Ed., 2002.
4. Vasudev Bhaskaran, Konstantinos Konstantinides, “Image and Video Compression Standards”, Kluwer Academic Publishers, 2nd Ed., 2003.
5. Mark Nelson, Jean-Loup Gailly, “The Data Compression Book”, John Wiley & Sons, 2nd Ed., 1995.
6. John Miano, “Compressed Image File Formats”, Addison Wesley Professional, 1st Ed., 1999.
7. Peter Wayner, “Compression Algorithms for Real Programmers”, Morgan Kaufmann, 1st Ed., 1999.
8. Yao Wang, Jorn Ostermann, Ya-Qin Zhang, "Video Processing and Communications", Pearson, 1st Ed., 2001.
9. Alan C. Bovik, "The Essential Guide to Video Processing", Academic PRes, 2nd Ed., 2009
10. A. Murat Tekalp, "Digital Video Processing", Prentice Hall, 2nd Ed., 2015.

24-479-0212: Natural Language Processing with Deep Learning

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

Natural language processing (NLP) is one of the most important technologies of the information age. Applications of NLP are everywhere because people communicate mostly everything in language: web searches, advertisements, emails, customer service, language translation, radiology reports, etc. Recently, deep learning approaches have obtained very high performance across many different NLP tasks. In this course, students will learn to implement, train, debug, visualize, and invent their neural network models. The course provides a deep excursion into cutting-edge research in deep learning applied to NLP

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the neural network approach to learning and processing natural language data | Understand |
| CO2 | Know advanced concepts in natural language processing | Understand |
| CO3 | Learn to implement, train, debug, and visualize deep neural network models for language processing | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 2 | 3 | 3 | - | - |
| CO2 | 3 | - | - | 2 | 3 | 3 | - | - |
| CO3 | 3 | - | - | 2 | 3 | 3 | 2 | - |

Course Content

1. Word Vectors - Singular Value Decomposition - Skip-gram - Continuous Bag of Words (CBOW) - Negative Sampling- Distributed Representations of Words and Phrases and their Compositionality Efficient Estimation of Word Representations in Vector Space - Advanced word vector representations- language models-softmax-single layer networks
2. Neural Networks and backpropagation for named entity recognition -A Neural Network for Factoid Question Answering over Paragraphs - Grounded Compositional Semantics for Finding and Describing Images with Sentences - Deep Visual-Semantic Alignments for Generating Image Descriptions-Recursive Deep Models for Semantic Compositionality over a Sentiment Treebank
3. Introduction to Tensorflow- Large - Scale Machine Learning on Heterogeneous Distributed Systems.

Recurrent neural networks for language modeling and Extensions of recurrent neural network language model-Opinion Mining with Deep Recurrent Neural Networks

4. GRUs and LSTMs for machine translation- Recursive neural networks for parsing- Parsing with Compositional Vector Grammars - Subgradient Methods for Structured Prediction-Parsing Natural Scenes and Natural Language with Recursive Neural Networks - Recursive Deep Models for Semantic Compositionality Over a Sentiment Treebank-Dynamic Pooling and Unfolding Recursive Autoencoders for Paraphrase Detection - Improved Semantic Representations From Tree-Structured Long Short-Term Memory Networks
5. Convolutional neural networks for sentence classification - Sequence to Sequence with Neural Networks - Neural Machine Translation by Jointly Learning to Align and Translate - Dynamic Memory Networks for NLP

References

1. Yoav Goldberg, Neural Network Methods for Natural Language Processing, Morgan & Claypool Publishers, 1ed, 2017
2. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, 1e, MIT Press, 2017
3. Nikhil Buduma and Nicholas Locascio, Fundamentals of Deep Learning: Designing NextGeneration Machine Intelligence Algorithms, 1e, Shroff/O'Reilly, 2017
4. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, 1e, Shroff/O'Reilly, 2017

24-479-0301: Elective - MOOC

Core/Elective: Elective

Semester: 3

Credits: 2

Course Description

A credit-based MOOC course of a minimum of 12 weeks duration or three non-credit-based MOOC courses of 4 weeks duration from SWAYAM/NPTEL/any other platforms approved by the Department council.

24-479-0303: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: **3**

Credits: **15**

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the first part of the work, the student shall submit an interim dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva- voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in-depth knowledge and thoughtful application through the detailed analysis of the chosen research problem. | Analyze |
| CO2 | Assesses the gap in knowledge by acquiring knowledge about previous works, their interpretation, and application. | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Apply |
| CO4 | Organizes the interim dissertation content with proper structure and sequencing. | Apply |
| CO5 | Demonstrates academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | 3 | 3 | - | 3 |
| CO2 | 3 | - | - | 3 | 3 | 3 | - | 3 |
| CO3 | 3 | - | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | 3 | - | - | 3 | - | - | 3 |
| CO5 | - | 3 | - | - | 3 | - | - | 3 |

24-479-0401: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: **4**

Credits: **17**

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the work, the student shall submit a final dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva-voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in-depth knowledge and thoughtful application through the detailed analysis of the problem chosen for the study | Analyze |
| CO2 | Assesses the gap by acquiring knowledge about the previous works, and its interpretation and application | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Apply |
| CO4 | Organize the interim dissertation content with proper structure and sequencing | Apply |
| CO5 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |
| CO6 | Show ability to evaluate and reflect on critical questions. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | 3 | 3 | 3 | - | - | 3 |
| CO2 | 3 | - | 3 | 3 | 3 | - | - | 3 |
| CO3 | 3 | - | - | 3 | 3 | - | - | 3 |
| CO4 | - | 3 | - | - | 3 | - | - | 3 |
| CO5 | - | 3 | - | - | 3 | - | - | 3 |
| CO6 | 3 | - | - | - | 3 | - | - | 3 |

Learning Outcomes and Assessment

Each course's learning outcomes will be assessed based on one or many methods, including the internal written tests, quizzes, presentations, seminars, assignments in the form of lab exercises, and group projects. The above assessment methods will be attentively created to support the intended learning outcomes that have been set out for a particular course. The program outcome attainment is measured using the CO/PO mappings.

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY



DEPARTMENT OF COMPUTER SCIENCE

PROGRAMME STRUCTURE & SYLLABUS

[2024 ADMISSION ONWARDS]

M.TECH. COMPUTER SCIENCE AND ENGINEERING
(ARTIFICIAL INTELLIGENCE AND SOFTWARE ENGINEERING)

**SYLLABUS FOR
OUTCOME-BASED EDUCATION**

**MASTER OF TECHNOLOGY (M.TECH.) COMPUTER SCIENCE
AND ENGINEERING (ARTIFICIAL INTELLIGENCE AND
SOFTWARE ENGINEERING)**

(2024 admission onwards)

Program Outcomes (PSO) for M.Tech. Computer Science and Engineering (Artificial Intelligence and Software Engineering)

After the completion of M.Tech. programme, the students will be able to:

PO1: Elicit deeper and current knowledge through research/exploration leading to development work with a motivation to solve practical problems.

PO2: Communicate effectively through well-written technical documentation as well as audio-visual presentations.

PO3: Recognize the importance of entrepreneurship and innovation to create value and wealth.

PO4: Acquire mastery in the topic of study at an exceedingly higher level.

Program Specific Outcomes (PSO) for M.Tech. Computer Science and Engineering (Artificial Intelligence and Software Engineering)

After the completion of M.Tech. programme, the students will be able to:

PSO1: Attain comprehensive understanding of advanced theories and models in Computer Science, Artificial Intelligence, and Software Engineering.

PSO2: Design and integrate robust, scalable, and maintainable software systems and applications using AI components, including microservices architectures and cloud-native technologies.

PSO3: Implement software development process, lead a software development team and manage software projects.

PSO4: Enhance research skills and conduct independent research, which could lead to technological innovations and improvements in the field of AI and Software Engineering.

| DEPARTMENT OF COMPUTER SCIENCE PROGRAMME STRUCTURE AND SYLLABUS (2024 ADMISSIONS) | | | | | | | |
|--|-------------|--|-------------------|--------------------------|------|------------------|-------|
| M.TECH. COMPUTER SCIENCE AND ENGINEERING (ARTIFICIAL INTELLIGENCE AND SOFTWARE ENGINEERING) | | | | | | | |
| Semester - I | | | | | | | |
| Sl. No. | Course code | Course Title | Core/ Elective | Credits | Lec. | Lab/ Tutorial | Marks |
| 1 | 24-502-0101 | Mathematics for Computing | C | 4 | 4 | 2 | 100 |
| 2 | 24-502-0102 | Artificial Intelligence and Machine Learning | C | 4 | 4 | 2 | 100 |
| 3 | 24-502-0103 | Design and Analysis of Algorithms | C | 4 | 4 | 2 | 100 |
| 4 | - | Elective I | E | 3 | 4 | 2 | 100 |
| 5 | - | Elective II | E | 3 | 4 | 2 | 100 |
| Total for Semester I | | | | 18 | 20 | 10 | 500 |
| Electives | | | | | | | |
| 24-502-0104: Cloud Computing and Internet of Things | | | | | | | |
| 24-502-0105: Big Data Analytics | | | | | | | |
| 24-502-0106: Software Quality Management | | | | | | | |
| 24-502-0107: Quantum Computing | | | | | | | |
| 24-502-0108: Advanced Data Mining | | | | | | | |
| 24-502-0109: Information Retrieval and Web search | | | | | | | |
| 24-502-0110: Social Network Analytics | | | | | | | |
| Semester - II | | | | | | | |
| Sl. No. | Course code | Course Title | Core/ Elective | Credits | Lec. | Lab/ Tutorial | Marks |
| 1 | 24-502-0201 | Software Architecture and Design Thinking | C | 4 | 4 | 2 | 100 |
| 2 | 24-502-0202 | Agile Software Engineering | C | 4 | 4 | 2 | 100 |
| 3 | 24-502-0203 | Deep Learning | C | 4 | 4 | 2 | 100 |
| 4 | 24-502-0204 | Seminar | C | 1 | 0 | 3 | 100 |
| 5 | - | Elective III | E | 3 | 4 | 2 | 100 |
| 6 | - | Elective IV | E | 3 | 4 | 2 | 100 |
| Total for Semester II | | | | 19 | 20 | 13 | 600 |
| Electives | | | | | | | |
| 24-502-0205: Blockchain Technology | | | | | | | |
| 24-502-0206: Explainable Deep learning Models | | | | | | | |
| 24-502-0207: Generative AI models | | | | | | | |
| 24-502-0208: Soft computing | | | | | | | |
| 24-502-0209: Complex Networks: Theory and Applications | | | | | | | |
| 24-502-0210: Advances in Databases | | | | | | | |
| Semester - III | | | | | | | |
| 1 | 24-502-0301 | Elective - MOOC | E | 2 | 0 | 10 | 100 |
| 2 | 24-502-0302 | Internship * | C | 1 | 0 | 0 | 100 |
| 3 | 24-502-0303 | Dissertation & Viva Voce | C | 15 | 0 | 20 | 100 |
| Total for Semester III | | | | 18 | 0 | 30 | 300 |
| Semester - IV | | | | | | | |
| 1 | 24-502-0401 | Dissertation & Viva Voce | C | 17 | 0 | 30 | 100 |
| Total credits for Degree: 72 | | | | Total Marks: 1500 | | | |
| *The students should complete the Course 24-502-0302 : Internship during the Vacation period (May-June) | | | | | | | |

24-502-0101: Mathematics for Computing

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

This course introduces the study of mathematical structures that are fundamentally discrete in nature. The course is intended to cover the main aspects which are useful in studying, describing and modeling of objects and problems in the context of Linear Algebra, computer algorithms and programming languages.

Course Outcomes (CO)

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

| CO | Couse Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Analyse the different methods for proving the correctness of the theorems and problems. | Analyse |
| CO2 | Understand and apply the basic concepts of Linear Algebra. | Apply |
| CO3 | Understand and apply the basic aspects of Descriptive statistics. | Apply |
| CO4 | Understand and apply the fundamentals of probability theory. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 3 | - | 2 |
| CO2 | 3 | 3 | - | - | 2 | 2 | - | 2 |
| CO3 | 3 | 3 | - | - | 2 | 2 | - | 2 |
| CO4 | 3 | 3 | - | - | 3 | 2 | - | 2 |

Course Content

1. Introduction – proofs – propositions – predicates and quantifiers – truth tables – first order logic – satisfiability – pattern of proof – proofs by cases – proof of an implication – proof by contradiction – proving iff – sets – proving set equations – Russell’s paradox – well-ordering principle – induction – invariants – strong induction – structural induction
2. Vectors-Coordinate system-vector addition-vector multiplication-Linear combinations, span, and basis vectors-Matrix multiplication as composition-Three-dimensional linear transformations-The determinant-Inverse matrices, column space and null space- Nonsquare matrices as transformations between dimensions-Dot products and duality-Cross products-Cross products in the light of linear transformations-Cramer's rule-Change of basis-Eigenvectors and eigenvalues-vector spaces
3. Descriptive statistics: histogram, sample mean and variance, order statistics, sample covariance, sample covariance matrix – Frequentist statistics: sampling, mean square error, consistency, confidence intervals,

parametric and non-parametric model estimation

4. Probability theory: probability spaces, conditional probability, independence – Random variables: discrete and continuous random variables, functions of random variables, generating random variables – Multivariate random variables: joint distributions, independence, generating multivariate random variables, rejection sampling – Expectation: Mean, variance and covariance, conditional expectation
5. Random process: definition, mean and autocovariance functions, iid sequences, Gaussian and Poisson process , random walk – Convergence of random process: types of convergence, law of large numbers, Central limit theorem, monte carlo simulation – Markov chains: recurrence, periodicity, convergence, markov-chain monte carlo- Gibbs sampling, EM algorithm, variational inference

References

1. Bronson, R., Costa, G.B., Saccoman, J.T. and Gross, D., Linear algebra: algorithms, applications, and techniques. 4e, 2023.
2. Eric Lehman, F Thomson Leighton, Albert R Meyer, Mathematics for Computer Science, 1e, MIT, 2010.
3. Susanna S. Epp, Discrete Mathematics with Applications, 4e, Brooks Cole, 2010.
4. Gary Chartrand, Ping Zhang, A First Course in Graph Theory, 1e, Dover Publications, 2012. in
5. John Tsitsiklis. 6.041SC Probabilistic Systems Analysis and Applied Probability. Fall 2013. Massachusetts Institute of Technology: MIT OpenCourseWare. <https://ocw.mit.edu>
6. Albert Meyer. 6.844 Computability Theory of and with Scheme. Spring 2003. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>.
7. Michael Mitzenmacher and Eli Upfal; Probability and Computing, 2ed, Cambridge University Press, 2017

Online Resources: Course notes of Carlos Fernandez-Granda, DS-GA 1002: Probability and Statistics for Data Science https://cims.nyu.edu/~cfgranda/pages/DSGA1002_fall17/index.html

24-502-0102: Artificial Intelligence and Machine Learning

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

Machine learning is programming computers to optimize a performance criterion using example data or past experience. This course is to discuss many methods that have their bases in different fields: statistics, pattern recognition, neural networks, artificial intelligence, signal processing, control, and data mining. Major focus of the course is on the algorithms of machine learning to help students to get a handle on the ideas, and to master the relevant mathematics and statistics as well as the necessary programming and experimentation.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|--|------------------|
| CO1 | Understand and explain the different types of the learning process, and key ethical considerations. | Understand |
| CO2 | Learn to effectively prepare data for machine learning models through data cleaning, feature selection, and dimensionality reduction. | Apply |
| CO3 | Implement and interpret linear and non-linear regression models, while comparing various classification techniques including tree-based, kernel, and ensemble methods. | Apply |
| CO4 | Gain practical knowledge in identifying data clusters using various algorithms and discovering hidden patterns through association rule learning. | Analyze |
| CO5 | Understand the basic building blocks of neural networks, implement the backpropagation algorithm, and explore the concept of MDPs and Q-learning. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 1 | 1 | 2 |
| CO2 | 3 | - | - | - | 3 | 1 | 1 | 2 |
| CO3 | 3 | - | - | 3 | 3 | 1 | 3 | 2 |
| CO4 | 3 | - | - | 3 | 3 | 1 | 2 | 2 |
| CO5 | 3 | - | - | 3 | 3 | 1 | 3 | 2 |

Course Content

1. Introduction to AI - What is AI? A Brief History of AI - Different types of AI - Applications of AI - Problem Solving Methods – Heuristics. Knowledge Representation and Reasoning - Planning and Decision-Making; Ethics and Societal Impact of AI.
2. Machine Learning Fundamentals - Concept of Machine Learning: Definition, applications, types of learning (supervised, unsupervised, reinforcement) - Hypothesis Spaces and Inductive Bias - Learning Process- Machine Learning Ethics and Bias. Data Preprocessing and Feature Engineering: Data Representation - Data Preprocessing - Features and Types - Dimensionality Reduction – Feature Identification - Feature selection – Feature extraction - Feature Importance-High dimensional data and Manifolds.
3. Regression and Classification - Regression: Linear Regression – Non-Linear regression – evaluation metrics for regression– Classification: Binary, multi-class, and multi-label classification – lazy learners - tree-based techniques - kernel-based techniques - probabilistic techniques - and ensembled techniques – evaluation metrics for classification.
4. Clustering and Rule Mining - Clustering: Partitioning based – hierarchical based – density based– grid-based – model based - Rule mining: Apriori algorithm, FB Growth - association rules. Outlier Detection - LOF.
5. Artificial Neural Networks and Reinforcement Learning -Neural Networks: McCulloch-Pitts neurons, Hebb’s networks, Hopfield networks, Boltzmann machines, Perceptrons, multilayer perceptrons, backpropagation. Reinforcement Learning: Markov Decision Processes (MDPs), Q-learning.

References

1. Ethem Alpaydin, Introduction to Machine Learning, 3e, MIT Press, 2014
2. Tom M. Mitchell, Machine Learning, McGraw Hill Education; 1e, 2017
3. Stephen Marsland, Machine Learning, An Algorithmic Perspective, 2e, CRC Press, 2015
4. Giuseppe Bonaccorso, Machine Learning Algorithms, 1e, Packt Publishing Limited, 2017
5. Ethem Alpaydin, Machine Learning- The New AI, MIT Press, 1e, 2016
6. Andrew Ng, Machine Learning Yearning, ATG AI (Draft version), 1e, 2018
7. Rohit Singh, Tommi Jaakkola, and Ali Mohammad. *6.867 Machine Learning*. Fall 2006. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>
8. Andrew Ng, <https://www.coursera.org/learn/machine-learning>

24-502-0103: Design and Analysis of Algorithms

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

The course covers the foundational algorithms in depth. The course helps in understanding the working and complexity of the fundamental algorithms and to develop the ability to design algorithms to attack new problems.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|---|------------------|
| CO1 | Understand the basic concepts of design and analysis of fundamental algorithms. | Understand |
| CO2 | Develop the ability to design algorithms to attack new problems. | Apply |
| CO3 | Prove the correctness of algorithms. | Analyze |
| CO4 | Develop the ability to analyze the complexity of algorithms. | Analyze |
| CO5 | Understand Complexity classes, concepts of P and NP problems | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | 3 | 3 |
| CO2 | 3 | - | - | 3 | 3 | - | 3 | 3 |
| CO3 | - | 3 | - | 3 | 3 | - | 3 | 3 |
| CO4 | 3 | 3 | - | - | 3 | - | 3 | 3 |
| CO5 | 3 | - | - | 3 | 3 | - | 3 | 3 |

Course Content

1. Introduction to design and analysis of algorithms, models of computation, correctness proofs, insertion sort, computational complexity, Master theorem , proof of Master theorem, merge sort, heaps, heap sort, binary search, binary search trees.
2. Graph algorithms, BFS and DFS, Dijkstra's algorithm, proof of correctness of Dijkstra's algorithm, Complexity analysis of Dijkstra's algorithm , Negative weight edges and cycles , Bellman-Ford algorithm, proof of correctness and complexity of Bellman-Ford, All pairs shortest paths, Floyd- Warshall algorithm, proof of correctness and complexity, Minimum Spanning Trees , Prim's algorithm, Cut property, Kruskal's algorithm, proof of correctness and complexity analysis of Kruskal's Algorithm, Maximum-Flow networks, Ford-Fulkerson method, proof of correctness and complexity, Edmonds-Karp algorithm
3. Probability review, Experiments, outcomes, events, Random variables, Expectation, Linearity of Expectation,

Indicator Random Variables, Hiring Problem, Quicksort , Best case and Worst case complexity, Randomized Quicksort , Average case complexity , Hashing, Chaining, Open Addressing, Universal Hashing, Perfect Hashing , Analysis of hashing operations

4. Dynamic Programming , Rod-cutting problem, Recursive formulation, Bottom-up reformulation of recursive algorithms, Optimal Substructure Property, Matrix chain multiplication, Complexity of dynamic programming algorithms, Sequence Alignment , Longest common subsequence, Greedy algorithms, Optimal substructure and greedy-choice properties , 0-1 and fractional Knapsack problems, Huffman coding
5. P vs NP, NP Hardness, Reductions, Travelling Salesman Problem, NP-Completeness, SAT, 2- SAT and 3-SAT, Vertex Cover

References

1. Michale T Goodrich and Roberto Tamassia, Algorithm Design and Applications, Wiley, 2014
2. Thomas H. Cormen et al, Introduction to Algorithms, MIT Press; 4th edition 2022.
3. Jon Kleinberg, Eva Tardos, Algorithm Design, Pearson; 1st edition August 2013.
4. Robert Sedgewick, Kevin Wayne, Algorithms, Addison Wesley; 4th edition 2011.
5. Steven S. Skiena, The Algorithm Design Manual, Springer; 3rd ed. October 2020

24-502-0104: Cloud Computing and Internet of Things

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

Cloud computing is an overarching concept where computation has moved from on premise to public/private servers commonly addressed as Cloud. Internet of Things is a specialized area of computing having an interdisciplinary nature. In this course, the advent of virtualization, later transformation from on-premise distributed computing to cloud computing and different models provided will be discussed. IoT deals with edge devices communicating with the cloud and it requires knowledge on lightweight communication protocols, data visualization, etc. We learn to create IoT solutions based on public platforms, discuss its security vulnerabilities and remedies.

Course Outcomes (CO)

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand various basic concepts related to cloud computing technologies. | Understand |
| CO2 | Explore cloud technologies, architectures, and standards | Understand |
| CO3 | Design methodologies and do programming for building cloud applications. | Apply |
| CO4 | Understand the basic concepts of design of Internet of Things. | Understand |
| CO5 | Develop the engineering skills to build internet of things solutions. | Apply |
| CO6 | Understand security vulnerabilities of cloud and apply solutions | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | - | 3 | - | - | - |
| CO3 | - | 3 | - | 3 | - | 3 | 3 | - |
| CO4 | 3 | - | - | 3 | - | - | 3 | - |
| CO5 | - | - | - | 3 | - | 2 | - | - |
| CO6 | 1 | - | - | 3 | - | 2 | - | - |

Course Content

1. Cloud Computing Overview: On-premise computing, client-server model, Distributed computing. Virtualization: virtual machines, hypervisor, full and para virtualization. Benefits of cloud computing, Edge and fog computing. Automated build management, deployment and monitoring of applications. Containers and docker.

2. Cloud architecture: Layers in cloud architecture, Hosting and management of applications. Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS). Scalability and reliability in cloud. Examples for each model. Web and Mobile applications communicating with cloud. Microservices vs Monolithic architectures. Applications of cloud computing healthcare, smart homes, smart grid, etc.
3. Introduction to Internet of Things. Embedded Systems: Sensors and actuators, SCADA, Cyber Physical Systems. Devices for IoT. Gateways and Routers. Time series data, measurement and acquisition of data. MQTT Protocol: broker, publish-subscribe, Mosquitto. Connectivity for IoT: Ethernet, Wireless, Bluetooth Low Energy, Zigbee, Mobile, LoRA, RFID.
4. Programming for IoT: Hosting IoT server in cloud. Using public Cloud IoT platforms: AWS/Azure/Google Cloud Etc. IoT Core, storing data, Analytics using public IoT platforms. Communicating from edge devices to gateway: Programming for Arduino/Raspberry Pi or Python compatible boards. Data Representation and Visualization: Building dashboards and mobile apps for IoT Analytics. Applications of IoT: Diagnostics, Maintenance and Predictive Analytics.
5. Cloud security: Authentication and Authorization, Tokens, API Key, Identity and Access Management in cloud. Threat analysis for IoT: Types of Cyber Attacks on cloud and IoT and techniques to prevent such attacks. Securing IoT and Cloud: Encryption of data, symmetric and asymmetric key encryption. Digital Signatures and certificates.

References

1. Toby Velte, Anthony Velte, Robert Elsenpeter: Cloud Computing, A Practical Approach, 1e, McGraw-Hill Education, 2009.
2. Rajkumar Buyya, James Broberg, Andrzej Goscinski: Cloud Computing: Principles and Paradigms, 1e, Wiley, 2013.
3. Giacomo Veneri and Antonio Capasso, Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0, 1st Edition, Packt Publishing, 2018.
4. Mayur Ramgir, Internet of Things: Architecture, Implementation and Security, 1st Edition, Pearson, 2019.
5. R. Buyya, S N. Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley Series on Parallel and Distributed Computing, 1st Edition, Wiley, 2019.
6. Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, 2nd Edition, MIT Press, 2017.

24-502-0105: Big Data Analytics

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

Big Data concerns large-volume, complex, growing data sets with multiple, autonomous sources. With the fast development of networking, data storage, and the data collection capacity, Big Data is now rapidly expanding in all science and engineering domains. The traditional data mining algorithms also need to be adapted for dealing with the ever-expanding datasets of tremendous volume.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Build practical skills on developing MapReduce jobs. | Apply |
| CO2 | Explain the search algorithms that perform efficiently on massive datasets. | Understand |
| CO3 | Explain the algorithms for data stream processing. | Understand |
| CO4 | Explain the link analysis methods in the context of social networks and PageRank algorithms. | Understand |
| CO5 | Demonstrate the power of some of the online algorithms for massive data. | Apply |
| CO6 | Explain the randomized, approximate and one-pass algorithms for mining from massive datasets. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | - | - | 3 | - |
| CO2 | 3 | - | - | - | 3 | - | 3 | - |
| CO3 | 3 | - | - | - | 3 | - | 3 | 2 |
| CO4 | 3 | - | - | - | - | - | 3 | 3 |
| CO5 | 3 | - | - | 3 | - | - | 3 | - |
| CO6 | 3 | 3 | - | - | 3 | - | 3 | - |

Course Content

1. Introduction to MapReduce – the map and reduce tasks, MapReduce workflow, fault tolerance. - Algorithms for MapReduce – matrix multiplication, relational algebra operations- Complexity theory for MapReduce
2. Locality-Sensitive Hashing - shingling of documents, min-hashing. Distance measures, nearest neighbors,

frequent itemsets- LSH families for distance measures, Applications of LSH- Challenges when sampling from massive data

3. Mining data streams – stream model, stream data sampling, filtering streams – bloom filters, counting distinct elements in a stream - Flajolet-Martin algorithm. Moment estimates - Alon-Matias-Szegedy algorithm, counting problems for streams, decaying windows
4. MapReduce and link analysis- PageRank iteration using MapReduce, topic-sensitive-PageRank - On-line algorithms – Greedy algorithms, matching problem, the adwords problem – the balance algorithm
5. Computational model for data mining – storage, cost model, and main memory bottleneck. Hash based algorithm for mining association rule – improvements to a-priori, park-chen-yu algorithm, multistage algorithm, approximate algorithm, limited-pass algorithms – simple randomized algorithm, Savasere, Omiecinski, and Navathe algorithm, Toivonen algorithm

References

1. Jure Leskovec, Rajaraman, A., & Ullman, J. D., Mining of Massive Datasets, Cambridge University Press, 2e, 2016
2. Charu C. Aggarwal, Data Streams: Models and Algorithms, 1e, Springer, 2007
3. Michael I Jordan et.al , Frontiers in Massive Data analysis, 1e, National Academies Press, 2013
4. Nathan Marz & James Warren, Big Data: Principles and best practices of scalable realtime data systems, Manning Publications, 2015

24-502-0106: Software Quality Management

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

This course discusses basic software project quality management principles and techniques as they relate to software project planning, monitoring and control. This course describes the basics of software verification and validation planning with an emphasis on software peer reviews and software testing. The course also covers software configuration management, technical metrics for software.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Understand the basics and benefits of software quality engineering | Understand |
| CO2 | Plan, implement and audit a Software Quality Management program for their organization | Apply |
| CO3 | Select, define, and apply software measurement and metrics to their software products, processes and services | Apply |
| CO4 | Understand the fundamentals of the configuration management process to include configuration identification, configuration control, status accounting, and audits | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | - | - | - | 2 | 2 | - | - | - |
| CO2 | 1 | - | - | 1 | 1 | 2 | 1 | - |
| CO3 | 2 | - | - | 2 | 2 | 1 | - | 1 |
| CO4 | - | - | - | 2 | 2 | 1 | - | - |

Course Content

1. Introduction to software quality: Software Quality - Hierarchical models of Boehm and McCall
- Quality measurement - Metrics measurement and analysis - Gilb's approach -GQM Model
2. Tools for Quality - Ishikawa's basic tools - CASE tools - Defect prevention and removal - Reliability models
- Rayleigh model - Reliability growth models for quality assessment
3. Testing for reliability measurement Software Testing - Types, White and Black Box, Operational Profiles - Difficulties, Estimating Reliability, Time/Structure based software reliability - Assumptions, Testing methods, Limits, Starvation , Coverage, Filtering, Microscopic Model of Software Risk
4. Software reliability and availability - standards and evaluation of process - ISO 9000 - SEI Capability Maturity Model (CMM) - Software configuration management
5. Technical metrics for software - metrics for the analysis model - metrics for design model - metrics for source

code - metrics for testing - metrics for maintenance - technical metrics for object oriented systems - distinguishing characteristics - class oriented metrics -operation oriented metrics - testing metrics -project metrics

References

1. Allan C. Gillies, Software Quality: Theory and Management, 3e, Cengage, 2003
2. Ron S Kenett, E. R Baker, Software Process Quality- Management and Control, 1e, CRC, 1999
3. Stephen H. Kan , Metrics and Models in Software Quality Engineering, 1e, AW, 2014
4. Patric D. T.O connor , Practical Reliability Engineering, 5e, John Wesley & Sons, 2011
5. Roger S. Pressman, Software Engineering - A practitioner's approach, 8e, McGraw Hill,2014

24-502-0107: Quantum Computing

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

This course introduces concepts of Quantum Computing. This includes representation of quantum information and use of quantum algorithms. The course will cover design of quantum circuits and provide understanding of quantum noise and quantum cryptography.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Understand the basic concepts of Quantum Computing. | Understand |
| CO2 | Examine quantum representation of information and encryption. | Analyze |
| CO3 | Design quantum circuits using qubit gates. | Apply |
| CO4 | Apply quantum algorithms for computation. | Apply |
| CO5 | Understand quantum noise and error correction for fault tolerant computation. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | 1 | - | - | 2 | - | - | - |
| CO2 | 1 | - | - | - | 1 | 1 | 1 | - |
| CO3 | 2 | 2 | - | 2 | 2 | 1 | - | 1 |
| CO4 | 1 | 2 | - | 1 | 1 | - | - | - |
| CO5 | 2 | 1 | - | 2 | 2 | 2 | 1 | 1 |

Course Content

1. Introduction to Quantum Computation: Quantum bits, representation of a qubit and multiple qubits. Quantum mechanics, Probabilities and measurements, entanglement, density operators and correlation, Measurements in bases other than computational basis.
2. Quantum correlations: Bell inequalities and entanglement, Schmidt decomposition, super-dense coding, teleportation, PPT criterion. Quantum Circuits: single qubit operations, multiple qubit gates, Universal quantum gates, design of quantum circuits.
3. Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, quantum search.
4. Quantum Information and Cryptography: Comparison between classical and quantum information theory. Shannon entropy, noiseless coding, Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem.
5. Noise and error correction: Quantum noise and quantum operations, Flip code, The Shor code, Quantum error correction, Stabilizer codes, Hamming bound. fault-tolerant quantum computation.

References

1. Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press, 10th Edition, 2010.
2. J. Hidary, Quantum Computing: An Applied Approach, 1st Edition, Springer Publishing, 2019.
3. David McMahon, Quantum computing explained, Wiley-Interscience, 1st Edition, John Wiley & Sons, Inc. Publication, 2008.
4. A. Peres. Quantum Theory: Concepts and Methods. 1st Edition, Springer, 1995.
5. J. Preskill, Lecture Notes on Quantum Information and Computation, California Institute of Technology, 2021.
6. Mark M. Wilde, Quantum information Theory, 1st Edition, Cambridge University Press, 2012.
7. D. A. Lidar and T. A. Brun, Quantum error correction, 1st Edition, Cambridge University Press, 2013.

24-502-0208: Advanced Data Mining

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

Data mining is the science of extracting hidden information from large datasets. This course offers a clear and comprehensive introduction to both data mining theory and Practice. All major data mining techniques will be dealt with and how to apply these techniques in real problems are explained through case studies.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the different techniques for analyzing data | Understand |
| CO2 | Understand statistical descriptions of data and its visualization. | Understand |
| CO3 | Evaluate different methods for mining frequent patterns, association and correlations in large data sets | Analyze |
| CO4 | Evaluate different methods for data classification, clustering, outlier detection and prediction. | Analyze |
| CO5 | Apply different spatial data mining techniques for the identification of spatial patterns. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | 1 | - | - | 2 | - | - | - |
| CO2 | 2 | 1 | - | - | 1 | - | 1 | - |
| CO3 | 1 | 1 | - | 2 | 2 | 1 | 1 | 1 |
| CO4 | 1 | 1 | - | 1 | 1 | 2 | 2 | - |
| CO5 | 1 | 1 | - | 2 | 2 | 2 | 1 | 1 |

Course Content

1. Statistical descriptions of data-data visualization-measuring data similarity and dissimilarity-data pre-processing-data cleaning-data integration-data reduction-data transformation-data warehouse modeling-design-implementation-data cube technology- queries by data cube technology- multidimensional data analysis in Cube space
2. Mining frequent patterns, associations and correlations – pattern mining in multidimensional space- colossal patterns- approximate patterns- applications- Mining data streams-Mining Sequence patterns in transactional databases- mining sequence pattern in Biological Data
3. Classification and prediction- decision tree induction-Bayesian classification-rule-based classification- neural networks-support vector machines-lazy learners-genetic algorithms- model evaluation-Cluster analysis-portioning methods- hierarchical methods- density based methods-grid based-probabilistic model based clustering- clustering high dimensional data- constraint based clustering- clustering high dimensional data-graph clustering methods
4. Outlier detection- outliers and outlier analysis- outlier detection methods-statistical approaches- proximity

- based approaches- clustering based approaches- classification based approaches-mining contextual and collective outliers- outlier detection in High-Dimensional data
5. Time series representation and summarization methods-mining time series data -Spatial data mining- spatial data cube construction-mining spatial association and co-location patterns-spatial clustering and classification methods-spatial trend analysis- Multimedia data mining-text mining- mining world wide web- trends in Data mining

References

1. Theophano Mitsa, Temporal Data mining, 1e, CRC Press, 2018
2. Jiawei Han & Micheline Kamber, Jian Pei, Data mining concepts and techniques, 1e, Elsevier, 2014
3. Shawkat Ali, A. B. M., and Wasimi, Saleh Ahmed. Data Mining: Methods and Techniques. Australia, Thomson, 2007.

24-502-0109: Information Retrieval and Web Search

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

A coherent treatment of classical and web based information retrieval that includes web search, text classification, text clustering, gathering, indexing and searching documents and methods of evaluating systems .

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand advanced techniques for text-based information retrieval. | Understand |
| CO2 | Understand Boolean and vector space retrieval models | Understand |
| CO3 | Evaluate various text classification techniques | Analyze |
| CO4 | Understand Web search characteristics, web crawling and link analysis | Understand |
| CO5 | Build working systems that assist users in finding useful information on the Web | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 1 | - | - | - | 2 | - | - | - |
| CO2 | 1 | - | - | - | 1 | - | - | - |
| CO3 | 2 | - | - | 2 | 2 | 1 | - | 1 |
| CO4 | 1 | - | - | - | 1 | - | - | - |
| CO5 | 2 | | | 2 | 2 | 2 | 1 | 1 |

Course Content

1. Taxonomy of IR Models – Classic models- Set theoretic model- Algebraic models- Probabilistic model- Structured text retrieval models- Models for browsing- Retrieval evaluations-Reference collections
2. Query languages-query operations-text and multimedia languages-Text operations-document preprocessing-matrix decompositions and latent semantic indexing-text compression –indexing and searching-inverted files-suffix trees- Boolean queries-sequential searching-pattern matching
3. Text Classification, and Naïve bayes-vector space classification-support vector machines and machine learning on documents-flat clustering –hierarchical clustering
4. Web search basics-web characteristics-index size and estimation- near duplicates and shingling-web crawling-distributing indexes- connectivity servers-link analysis-web as a graph- PageRank-Hubs and authorities- question answering
5. Online IR systems- online public access catalogs-digital libraries-architectural issues-document models - representations and access- protocols

References

1. Ricardo Baeza Yates, Berthier Ribeiro-Neto , Modern Information Retrieval: The Concepts and Technology behind Search, 3e, ACM Press, 2017
2. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze , Introduction to Information Retrieval, 1e, Cambridge University Press, 2008
3. Bruce Croft, Donald Metzler and Trevor Strohman, Search Engines: Information Retrieval in Practice, 1e, AW, 2009

24-502-0110: Social Network Analytics

Core/Elective: **Elective**

Semester: **1**

Credits: **3**

Course Description

The course on Social Network Analytics offers an in-depth exploration of the theory, methods, and applications of analyzing social networks. Social networks have become a powerful lens through which to understand human behavior, relationships, and information flow in various contexts including online platforms, organizations, communities, and societies. This course delves into the principles and techniques used to study, model, and analyze social networks, along with their practical applications in diverse domains.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the concept of semantic web and related applications. | Understand |
| CO2 | Learn knowledge representation using ontology. | Understand |
| CO3 | Understand human behavior in the social web and related communities. | Analyze |
| CO4 | Learn visualization of social networks. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 1 | - | - | - | 1 | - | - | - |
| CO2 | 1 | - | - | - | 1 | - | - | - |
| CO3 | 1 | - | - | 1 | 1 | - | - | - |
| CO4 | 1 | - | - | - | 1 | 1 | - | - |

Course Content

1. Introduction to Semantic Web: Limitations of current Web - Development of Semantic Web - Emergence of the Social Web - Social Network analysis: Development of Social Network Analysis - Key concepts and measures in network analysis - Applications of Social Network Analysis.
2. Ontology and their role in the Semantic Web: Ontology-based knowledge Representation - Ontology languages for the Semantic Web: Resource Description Framework - Web Ontology Language - Modelling and aggregating social network data: State-of-the-art in network data representation - Ontological representation of social individuals - Ontological representation of social relationships - Aggregating and reasoning with social network data.
3. Extracting evolution of Web Community from a Series of Web Archive - Detecting communities in social networks - Definition of community - Evaluating communities - Methods for community detection and mining - Applications of community mining algorithms - Tools for detecting communities social network infrastructures and communities

4. Understanding and predicting human behaviour for social communities - User data management - Inference and Distribution - Enabling new human experiences - Reality mining - Context - Awareness - Privacy in online social networks - Trust in online environment - Trust models based on subjective logic - Trust network analysis - Trust transitivity analysis - Combining trust and reputation - Trust derivation based on trust comparisons - Attack spectrum and countermeasures.
5. Graph theory - Centrality - Clustering - Node-Edge Diagrams - Matrix representation - Visualizing online social networks, Visualizing social networks with matrix-based representations - Matrix and Node-Link Diagrams - Hybrid representations - Applications - Cover networks - Community welfare - Collaboration networks - Co-Citation networks.

References

1. Peter Mika, —Social Networks and the Semantic Web, First Edition, Springer 2007.
2. Borko Furht, —Handbook of Social Network Technologies and Applications, 1st Edition, Springer, 2010.
3. Guandong Xu ,Yanchun Zhang and Lin Li, —Web Mining and Social Networking – Techniques and applications, First Edition, Springer, 2011.
4. Dion Goh and Schubert Foo, —Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively, IGI Global Snippet, 2008.
5. Max Chevalier, Christine Julien and Chantal Soulé-Dupuy, —Collaborative and Social Information Retrieval and Access: Techniques for Improved user Modelling, IGI Global Snippet, 2009.
6. John G. Breslin, Alexander Passant and Stefan Decker, —The Social Semantic Web, Springer, 2009.

24-502-0201: Software Architecture and Design Thinking

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description

This course introduces the essential concepts of software architecture. Software architecture is an abstract view of a software system distinct from the details of implementation, algorithms, and data representation. Architecture is, increasingly, a crucial part of a software organization's business strategy. Here we discuss how architecture is conceived and implemented and how design thinking plays a role in development of a software product.

Course Outcomes (CO)

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand need for better software architecture and factors affecting it | Understand |
| CO2 | Explore pattern oriented design and different types of software architectures | Analyze |
| CO3 | Understand design concepts and software models in cloud and mobile domains. | Understand |
| CO4 | Design products based on various design thinking approaches and representations | Apply |
| CO5 | Understand case studies of products and develop architectures based on design thinking | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | - | - | - | 2 | - | 1 | - |
| CO2 | 1 | - | - | - | 2 | 1 | 1 | - |
| CO3 | - | 2 | - | - | 2 | 2 | 1 | - |
| CO4 | - | 2 | - | 2 | 1 | - | 1 | 1 |
| CO5 | - | - | 2 | 2 | 1 | - | 1 | 1 |

Course Content

1. Software life cycle, Influences on Software architecture from stakeholders. Software Quality attributes, Guiding Quality Design Decisions. Designing for Availability, Interoperability, Modifiability, Performance, Security, Testability, and Usability. Designing Architecture: Architecturally Significant Requirement, Attribute driven design method, Views. Programming practises: Object oriented design.
2. Pattern oriented design: categories, relationship and Layers. Pipes and Filters architectural pattern, Blackboard, Distributed systems, Broker, Hardware-Software codesign. Model-View-Controller. Presentation-abstraction-control, Microkernel, Reflection. Whole-part design, Master-slave design, command processor, view handler, Forwarder-receiver, client-dispatcher-server, publisher-subscriber.
3. Architectures in Cloud and Mobile: On premise vs cloud, Mobile architectures: Android and IOS based application design. Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS). Multi-tenant implementation of software. Databases: RDBMS, NoSQL, timeseries, Redundancy. Use of Frameworks in coding. SOLID principles.
4. Design thinking: Understand, Define, Ideate, Prototype, Test. Double diamond approach, Research in Design Thinking: Quantitative vs Qualitative. Roles in design thinking: Equalizer, Archaeologist, Interpreter, Devil's advocate. Design of Business Strategy: Circle of influence, customer experience, Services and delivery.

Metrics for Design Thinking: Enquiries, Sales, referrals, impression, etc.

5. Design Thinking representations: Empathy map, Affinity diagram, mind map, journey map. Marketing. Designing for change and growth. Disruptive innovation, Blue ocean strategy, Cold start problem, tipping point, . Case studies in design thinking.

References

1. Len Bass, Paul Clements, Rick Kazman: Software Architecture in Practice, Third Edition, Pearson, 2012.
2. Frank Buchmann, Regine Meunier et. al.: Pattern-oriented Software architecture, A system of patterns, Volume 1, Wiley, 2008.
3. Beverly R Ingle: Design Thinking for Entrepreneurs and Small business, Apress, 2013.
4. Tim Brown: Change by Design: How Design Thinking Transforms Organizations and Inspire Innovations, Harper Collins, 2019.
5. Documenting Software Architectures, Views and Beyond, 2nd Edition. P. Clements, F. Bachmann, L. Bass, et. al. Adison-Wesley SEI series, 2010.
6. Nigel Cross, Design Thinking: Understanding how Designers Think and Work, Bloomsbury Visual Art, 2019.

24-502-0202: Agile Software Engineering

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description:

Computer software has become pervasive in our commerce, culture, transportation, medical, telecommunications, military, industrial, entertainment, office and our everyday activities. Software engineering is important because it enables us to model, design and build complex software systems in a timely manner and with high quality. This course discusses the processes, methods and tools for effective software development and project management in the agile way.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Create a software product architecture using UML | Apply |
| CO2 | Communicate with the development team using industry standard notations, designs and documentations. | Apply |
| CO3 | Estimate the cost of a software project and apply various techniques, metrics and strategies for testing software projects. | Analyze |
| CO4 | Work as a team leader by establishing goals and forming teams. | Apply |
| CO5 | Understand the user requirements and plan the development work using agile project management principles. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | - | - | 2 | 2 | - | 1 | - |
| CO2 | - | 2 | - | - | 2 | - | 2 | - |
| CO3 | 2 | - | - | 2 | 2 | - | 1 | - |
| CO4 | - | 1 | 1 | - | - | - | 3 | - |
| CO5 | 1 | - | - | 2 | 1 | 1 | 2 | - |

Course Content

1. Emergence of Software Engineering, Software design notations, Object-Oriented Analysis and Design using Unified Modelling Language (UML), Use Case Model Development, Object and Class Diagrams, Interaction Diagrams, Sequence models, Activity Diagrams, State Chart Diagrams, Package diagrams
2. Software Life Cycle Models, Waterfall Model, Prototyping Model, Spiral Model, Software Requirements Specification, SRS Document, Function-oriented Design, , Scheduling, Critical Path Method, PERT Charts, Gantt Charts, Organization and Team Structures
3. Metrics for Project Size Estimation, COCOMO Model, Software Quality, Software Quality Management System, Testing Concepts and Terminologies, Black-box Testing, White-Box Testing, Statement Coverage, Branch Coverage, Path Coverage, McCabe's Cyclomatic Complexity Metric, Software Maintenance.
4. Agile Principles, Variability and Uncertainty, Work in Process, Progress, Performance, Scrum Framework, Scrum Roles, Responsibilities & Characteristics of Product Owner, ScrumMaster, Development Team,

Sprints, Timeboxing, Sprint Planning, Sprint Execution

5. Product Backlog, Good Product Backlog Characteristics, Requirements and User Stories, Characteristics of Good Stories, Estimation and Velocity, PBI Estimation Units, Planning Poker, Scrum Planning Principles, Product Planning (Envisioning), Portfolio Planning, Release Planning, Sprint Planning

References

1. Agile: An Essential Guide to Agile Project Management, The Kanban Process and Lean Thinking + A Comprehensive Guide to Scrum, James Edge, Bravex Publications, 2020
2. Agile Software Engineering, Orit Hazzan and Yael Dubinsky, Springer London, 2008
3. Object Oriented Modeling and Design with UML, James Rumbaugh and Michael Blaha, Pearson Education India, 2nd edition, 2007
4. Software Engineering: A Practitioner's Approach, Roger Pressman, McGraw Hill, 9th Edn 2023
5. Fundamentals of Software Engineering, Rajib Mall, PHI Learning, 5th Edition 2018
6. Scrum: The Art of Doing Twice the Work in Half the Time, Jeff Sutherland and J.J. Sutherland, Currency; First Edition, 2014
7. Essential Scrum: a practical guide to the most popular agile process, Kenneth S. Rubin, Addison-Wesley, 2012
8. Effective Project Management: Traditional, Agile, Extreme, Hybrid, 8th Edition, Robert K. Wysocki; Wiley, 2019
9. Clean Code: A Handbook of Agile Software Craftsmanship, Robert C. Martin, Pearson, First edition 2008

24-502-0203: Deep Learning

Core/Elective: **Core**

Semester: 2

Credits: 4

Course Description:

Deep learning is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. This course describes deep learning techniques used by practitioners in industry, including deep feedforward networks, regularization, optimization algorithms, convolutional networks, sequence modeling, and practical methodology. This course is useful to students planning careers in either industry or research, and for software engineers who want to begin using deep learning in their products or platforms

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the need for Deep learning, Feed forward networks, Learning XOR, Gradient based Learning, Hidden units. | Understand |
| CO2 | Differentiate between training error and generalization error, Underfitting and Overfitting. And Identify Regularization strategies, Dataset Augmentation, Adversarial Training. | Analyze |
| CO3 | Describe the working of Convolution Operation, Sparse interactions, Parameter sharing, Equivariant representations, Pooling and Recurrent Neural Networks | Understand |
| CO4 | Understand different types of Autoencoders, Undercomplete Autoencoders, Regularized Autoencoders, Dimensionality Reduction. | Understand |
| CO5 | Explain Deep generative models like Boltzmann Machines, Restricted Boltzmann Machines. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | 1 | 3 | - | - | - |
| CO3 | 3 | 2 | - | 1 | 3 | - | - | - |
| CO4 | 3 | - | - | 1 | 3 | - | - | - |
| CO5 | 3 | 2 | - | 1 | 3 | - | - | - |

Course Content:

1. Deep Networks: Feed forward networks – Learning XOR- Gradient based Learning – Hidden units – Architecture design- Back propagation – Differentiation algorithms
2. Regularization for Deep Learning: Penalties-Constrained optimization-Under constrained problems- Dataset

- augmentation-Semi Supervised learning- Sparse representation- Adversarial training- Optimization for training deep models: Basic algorithms-Algorithms with adaptive learning rates
3. Convolutional Networks: Convolution-Pooling-Variants of pooling- Efficient convolutional algorithms – Recurrent and Recursive Nets: Recurrent Neural Networks-Deep Recurrent Networks- Recursive Neural Networks- Explicit memory
 4. Linear Factor Models: Probabilistic PCA- ICA – Slow feature analysis – Sparse coding – Autoencoders: UndercompleteAutoencoders – Regularized Autoencoders- Learning Manifolds- Applications of Autoencoders – Representation learning
 5. Deep generative models: Boltzmann Machines – RBM- Deep Belief Networks-Deep Boltzmann Machines- Convolutional Boltzmann Machines- Directed generative Nets

References

1. Nithin Buduma, Nikhil Buduma and Joe Papa, Fundamentals of Deep Learning, 2nd Edition, O'Reilly, 2022
2. Jon Krohn and Grant Beyleveld, Deep learning Illustrated, Addison-Wesley; 1st edition, 2019
3. M Gopal, Deep Learning, Pearson Education; 1st edition, 2022
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 1e, MIT Press, 2016
5. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, 1e, Shroff/O'Reilly, 2017

24-502-0204: Seminar

Core/Elective: **Core**

Semester: **2**

Credits: **1**

Course Description

The student has to prepare and deliver a presentation on a research topic suggested by the department before the peer students and staff. They also have to prepare a comprehensive report of the seminar presented.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Identify, read, and interpret an academic research article from the literature that is related to his/her academic area of interest and present it before the committee. | Analyze |
| CO2 | Organize and communicate technical and scientific findings effectively in written and oral forms. | Apply |
| CO3 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | 2 | - | 1 | 2 | - | - | - |
| CO2 | - | 2 | - | - | 2 | - | - | - |
| CO3 | 3 | 2 | - | 1 | 2 | - | - | - |

24-502-0205: Blockchain Technology

Core/Elective: **Elective**

Semester: 2

Credits: 3

Course Description

This course intends to provide a comprehensive insight into various Blockchain techniques. The objectives are to give an insightful introduction to the basic concepts of blockchain and its applications in various domains.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Understand the fundamentals of blockchain technology | Understand |
| CO2 | Understand the essentials of Bitcoin and beholding bitcoins as blockchains | Understand |
| CO3 | Analyze and design the Ethereum Blockchain | Analyze |
| CO4 | Build Factom Blockchains | Apply |
| CO5 | Analyze the powers of blockchains and their applications in various domains | Analyze |
| CO6 | Study the impact of blockchains on industry | Analyze |
| CO7 | Execute a mini project on blockchain | Apply |

Mapping with Programme Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | - | - | - | 1 | 3 | - | - | - |
| CO2 | - | - | - | 1 | 3 | - | - | - |
| CO3 | - | - | - | 1 | - | 3 | - | - |
| CO4 | - | - | - | 1 | - | 3 | 3 | - |
| CO5 | 3 | - | - | 1 | - | 3 | 3 | - |
| CO6 | - | - | 3 | 1 | 3 | 3 | - | - |
| CO7 | 3 | - | 3 | 3 | - | 3 | 3 | - |

Course Content

1. Introduction to blockchain: Structure of blockchains, Blockchain life cycle, working of a blockchain, picking a blockchain, exploring blockchain applications, building trust with blockchains, Blockchain in action: Use cases, introducing bitcoin blockchains.
2. Bitcoin & Ethereum blockchains: Understanding bitcoins, comprehending bitcoins as blockchains, analyzing Ethereum blockchains, introducing ripple and factom blockchains and their importance
3. Powerful blockchain platforms: Getting introduced to Hyperledger, Hyperledger vision, Hyperledger sawtooth, understanding the blockchain fabric, understanding business, and smart blockchains, IBM Blockchains, Stellar: an optimized blockchain

4. Industry impacts of blockchains: Blockchains in financial technology, Blockchains in various industries such as insurance, Government, Real-estate, health care, Telecommunication, Transportation, etc..
5. Case Study and mini-project: Studying different blockchain projects as a case study and submit a report and present the work, Designing a blockchain application as a mini-project, and presenting the work.

References

1. Blockchain and Crypto Currency, Editors: Makoto YanoChris DaiKenichi MasudaYoshio Kishimoto, 1st Edition, Springer, 2020.
2. Blockchain or Dummies, Tiana Laurence, 1st Edition , John Wiley & Sons, Inc, , 2017.
3. Blockchain Blueprint for a new economy, Melanie Swan, 1st Edition,O'Reilly, 2017.
4. Blockchain Technology: Applications and Challenges, Panda, S.K., Jena, A.K., Swain, S.K., Satapathy, S.C. , 1st Edition, Springer, 2021
6. Blockchain and Distributed Ledgers, Alexander Lipton and Adrien Treccani, 1st Edition, World Scientific Press, 2021

24-502-0206: Explainable Deep Learning Models

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description:

This course equips students with the essential skills and knowledge to navigate the complex landscape of Explainable Deep Learning Models (EDLMs). Students learn to apply a range of interpretability techniques, including feature importance analysis, rule-based models, and model-agnostic methods. By applying explainability techniques to real-world datasets and challenges, students develop practical expertise. Additionally, they gain a awareness of the ethical implications surrounding AI transparency and interpretability, preparing them to navigate these issues responsibly in their future endeavors.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Apply interpretability techniques to enhance the transparency of machine learning models. | Apply |
| CO2 | Evaluate and compare different interpretability methods. | Analyze |
| CO3 | Understand the trade-offs between model complexity and interpretability in diverse scenarios. | Analyze |
| CO4 | Apply explainability techniques to real-world datasets and challenges. | Apply |
| CO5 | Gain awareness of the ethical implications related to AI transparency and interpretability. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | - | - | 3 | - |
| CO2 | 3 | - | - | 1 | - | - | - | 3 |
| CO3 | 3 | 2 | - | 1 | 3 | - | - | - |
| CO4 | 3 | - | - | 1 | - | - | 3 | - |
| CO5 | 3 | 2 | - | 1 | 3 | - | - | - |

Course Content:

1. Introduction to Explainable AI - Science of Interpretable Machine Learning, Motivation, Challenges, and Mythos of Model Interpretability, Human Factors in Explainability, Interpreting Interpretability, XAI flow, Making ML models Explainable: Intrinsic Explanations, Post Hoc Explanations, Global or Local Explainability, Properties of Explanations.
2. Intrinsic Explainable models: Loss Function, Linear Regression, Logistic Regression, Decision Trees, KNN. Model Agnostic Methods For XAI: Global Explanations, Local Explanations, shap.KernelExplainer, Text Explainer, Gradient Explainer, Local Linear Surrogate Models (LIME): mathematical representation,

Bagging classifier, Boosting classifier, Decision Tree, Extra Trees, Creating Lime Explainer, SHAP for Boosted Trees

3. Post hoc Explanations - Explaining the Predictions of Any Classifier, Pitfalls, Challenges, and Evaluation of Feature Attributions, OpenXAI, The Disagreement Problem in Explainable Machine Learning, Counterfactual Explanations (or) Algorithmic Recourse, Learning Model-Agnostic Counterfactual Explanations for Tabular Data
4. Attention and Concept Based Explanations - Quantifying Interpretability of Deep Visual Representations, Interpretability Beyond Feature Attribution, Data Attribution and Interactive Explanation, Equitable Valuation of Data, Explainable Active Learning (XAL), Theory of Explainability and Interpreting Generative Models
5. Explainability for Fair Machine Learning - Connections with Robustness, Privacy, Fairness, and Unlearning, Right to Explanation and the Right to be Forgotten, Fairness via Explanation Quality, Mechanistic Interpretability and Compiled Transformers, Understanding and Reasoning in Large Language Models

References

1. Explainable AI with Python, Antonio Di Cecco and Leonida Gianfagna, Springer
2. Hands-On Explainable AI (XAI) with Python: Interpret, visualize, explain, and integrate reliable AI for fair, secure, and trustworthy AI apps, Denis Rothman, Packt publisher
3. Interpretable Machine Learning, by Christoph Molnar <https://christophm.github.io/interpretable-ml-book/84>
4. Interpretable Machine Learning with Python: Learn to build interpretable high performance models with hands-on real-world examples, by Serg Masís , Packt publisher

24-502-0207: Generative AI models

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

This course provides an overview of generative AI, covering foundational concepts, understanding how AI models can create new content, major models, practical applications like image and text generation and even discussing about prompt engineering

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Outline the scope and application of Generative AI | Understand |
| CO2 | Interpret different language models and their role in AI | Analyze |
| CO3 | Analyze the concept of GPT and its variants | Analyze |
| CO4 | Illustrating the core principles of GAN | Understand |
| CO5 | Understanding the concept and significance of prompt engineering | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | - | - | - |
| CO2 | 3 | - | - | 1 | 3 | - | - | - |
| CO3 | 3 | - | - | 1 | 3 | - | - | - |
| CO4 | 3 | - | - | 1 | 3 | - | 2 | - |
| CO5 | 3 | - | - | 1 | 3 | - | - | - |

Course Content

1. Introduction to Generative AI, Scope of Generative AI, Overview of generative models and their applications Importance of Generative AI in various domains, Ethical considerations and challenges
2. Introduction to language models and their role in AI, Traditional approaches to language modeling, Deep learning-based language models and their advantages, LLM architectures: RNNs, LSTMs, and Transformers
3. Understanding GPT (Generative Pre-trained Transformer) Introduction to GPT and its significance Pre-training and fine-tuning processes in GPT Architecture and working of GPT models Overview of GPT variants and their use cases
4. The core principles of GANs and their architecture. Different GAN architectures. Training and evaluating GANs, addressing common challenges. Exploring GAN applications in image generation and manipulation. Auto encoders
5. Prompt Engineering: Enhancing Model Outputs Understanding the concept and significance of prompt engineering Strategies for designing effective prompts Techniques for controlling model behavior and output quality

References

1. "The Artificial Intelligence and Generative AI Bible: The Most Updated and Complete Guide" by Alger Fraley
"Ripples of Generative AI: How Generative AI Impacts, Informs and Transforms Our Lives" by Jacob Emerson
2. "Neural Networks and Deep Learning" by Michael Nielsen
3. "Generative Adversarial Networks" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
4. "Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play" by David Foster
5. "Demystifying Prompt Engineering: AI Prompts at Your Fingertips (A Step-By-Step Guide)" by Harish Bhat
6. "Generative AI with Python and TensorFlow 2" by Joseph Babcock and Raghav Bali
7. "Generative AI with LangChain" by Ben Auffarth
8. "Generative AI in Practice" by Bernard Marr

24-502-0208: Soft Computing

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

The aim of this course is to cover fundamental concepts used in Soft computing. As part of this course the students will get exposure to Fuzzy logic, Artificial Neural Networks and optimization techniques using Genetic Algorithm. To provide hands - on practices to the students applications of Soft Computing techniques to solve a number of real life problems will be covered. This course will provide exposure to theory as well as practical systems and software used in soft computing.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Learn Fuzzy logic and its applications. | Understand |
| CO2 | Understand the basic concepts of artificial neural networks and its applications. | Understand |
| CO3 | Solve single-objective optimization problems using GAs. | Apply |
| CO4 | Solve multi-objective optimization problems using Evolutionary algorithms. | Apply |
| CO5 | Apply Soft computing techniques to solve problems in various application domains. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | | 3 - | - | - | | 3 - | - | - |
| CO2 | | 3 - | - | 1 | | 3 - | - | - |
| CO3 | | 3 | 2 - | 1 - | | - | 3 - | |
| CO4 | | 3 | 2 - | 1 - | | - | 3 - | |
| CO5 | | 3 - | - | 1 - | | - | 3 - | |

Course Content

1. Introduction to Soft Computing: Concept of computing systems-"Soft" computing vs "Hard" computing- Characteristics of Soft computing-Some applications of Soft computing techniques.
2. Fuzzy logic: Introduction to Fuzzy logic - Fuzzy sets and membership functions - Operations on Fuzzy sets - Fuzzy relations , rules , propositions, implications and inferences - Defuzzification techniques - Fuzzy logic controller design - Some applications of Fuzzy logic.
3. Genetic Algorithms: Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques -Basic GA framework and different GA architectures - GA operators: Encoding , Crossover , Selection , Mutation , etc.-Solving single - objective optimization problems usingGas.
4. Multi-objective Optimization Problem Solving: Concept of multi-objective optimization problems (MOOPs) and issues of solving them - Multi-Objective Evolutionary Algorithm (MOEA) - Non - Pare to approaches to solve MOOPs - Pareto - based approaches to solve MOOPs Some applications with MOEAs.

5. Artificial Neural Networks: Biological neurons and its working - Simulation of biological neurons to problem solving - Different ANNs architectures - Training techniques for ANNs Applications of ANNs to solve some real life problems.

References

1. Timothy J.Ross, Fuzzy Logic with Engineering Applications, 4e, Wiley, 2016.
2. S. Rajasekaran, and G.A.Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms : Synthesis and Applications,1e, Prentice Hall India,2003.
3. Melanie Mitchell, An Introduction to Genetic Algorithms , 1e, MITPress, 1998.
4. Nikola K.Kasabov, Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering, 1e, MITPress, 1996.
5. S.N.Sivanandam and S.N.Deepa, Principles of Soft Computing, 3e, Wiley, 2018.
6. Randy L. Haupt and Sue Ellen Haupt: Practical Genetic Algorithms, 2e, Wiley, 2004.
7. Simon Haykin: Neural Networks and Learning Machines, 3e, Pearson, 2009.
8. J.-S.R.Jang,C.-T.Sun,and E.Mizutani:Neuro Fuzzy and Soft Computing,1e,Pearson Education India, 2015.

24-502-0209: Complex Networks: Theory and Applications

Core/Elective: **Elective**

Semester: 2

Credits: 3

Course Description

Complex networks provide a powerful abstraction of the structure and dynamics of diverse kinds of interaction viz people or people-to-technology, as it is encountered in today’s inter-linked world. This course provides the necessary theory for understanding complex networks and applications built on such backgrounds.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Explain and appreciate complex networks and complex network systems as different from other network systems viz. computer networks, transportation networks, etc. | Analyze |
| CO2 | Explain the mathematical representation of complex networks in computer programs. | Understand |
| CO3 | Demonstrate random graph generation processes and associated properties. | Apply |
| CO4 | Discriminate various algorithms for community detection in complex networks. | Analyze |
| CO5 | Illustrate and explain the flow models used in complex networks for modelling social, economic, and biological systems. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 - | - | - | - | 3 - | - | - | - |
| CO2 | 3 - | - | - | 1 | 3 - | - | - | - |
| CO3 | 3 - | - | - | 1 - | - | - | 3 - | - |
| CO4 | 3 | 2 - | - | 1 | 3 - | - | - | - |
| CO5 | 3 | 2 - | - | 1 | 1 - | - | 3 - | - |

Course Content

1. Networks of information – Mathematics of networks – Measures and metrics – Large scale structure of networks – Matrix algorithms and graph partitioning
2. Network models – Random graphs – walks on graphs - Community discovery – Models of network formation – Small world model - Evolution in social networks – Assortative mixing- Real networks - Evolution of random network - Watts-Strogatz model – Clustering coefficient - Power Laws and Scale-Free Networks – Hubs - Barabasi-Albert model – measuring preferential attachment- Degree dynamics – nonlinear preferential attachment.
3. Processes on networks – Percolation and network resilience – Epidemics on networks – Epidemic modelling - Cascading failures – building robustness- Dynamical systems on networks – The Bianconi-Barabási model – fitness measurement – Bose-Einstein condensation

4. Models for social influence analysis – Systems for expert location – Link prediction – privacy analysis – visualization – Data and text mining in social networks - Social tagging
5. Social media - Analytics and predictive models – Information flow – Modelling and prediction of flow - Missing data - Social media datasets – patterns of information attention – linear influence model – Rich interactions

References

1. Mark J. Newman, *Networks: An introduction*, 1e, Oxford University Press, 2010
2. Charu C Aggarwal (ed.), *Social Network Data Analytics*, 1e, Springer, 2011
3. David Easley and Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning about a highly connected World*, 1e, Cambridge University Press, 2010
4. Albert-Laszlo Barabasi, *Network Science*, 1e, Cambridge University Press, 2016

24-502-0210: Advances in Databases

Core/Elective: **Elective**

Semester: **2**

Credits: **3**

Course Description

This is a second course in database systems which cover advanced aspects of database systems touching upon the theoretical advancements to handle the new areas and challenges related to the management of data. The course introduces the students to the frontiers of the classical database systems and takes them to the multidimensional data and the associated processing techniques. Later, a large multitude of specialty databases are introduced. This course consolidates the theory and practices pertaining to big data storages and cloud databases.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand various aspects of physical database design and usage analysis. | Understand |
| CO2 | Understand various aspects of Online Analytical Processing (OLAP) | Understand |
| CO3 | Understand the concepts of Object-Based Databases. | Understand |
| CO4 | Understand the concepts of Spatial and Temporal Data. | Understand |
| CO5 | Construct cloud database models. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO2 | 3 | - | - | 3 | 3 | 3 | - | - |
| CO3 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO4 | 3 | - | - | 3 | 3 | 2 | - | - |
| CO5 | 3 | 3 | - | - | 2 | 3 | - | - |

Course Content

1. Physical Database Design: The Physical Database Design Process - Data Volume and Usage Analysis - Controlling Data Integrity - Missing Data – Denormalization –Partitioning - File Organizations – Heap-Sequential-Indexed-Hashed – Non-unique indexing.
2. Online Analytical Processing: Recent Enhancements and Extensions to SQL - Analytical and OLAP

Functions–Multidimensional Analysis - New Data Types- New Temporal Features in SQL- Other Enhancements. Need for Data Warehousing – Architectures- Data Mart and Data Warehousing Environment - Real-Time Data Warehouse Architecture - Enterprise Data Model- Status/Event/Transient/Periodic Data - Derived Data - Star Schema and variations - Fact Tables - Dimension Tables - Normalization - Surrogate Key - Hierarchies - Unstructured Data.

3. Object-Based Databases: Complex Data Types - Structured Types and Inheritance in SQL - Table Inheritance - Array and Multiset Types in SQL - Object-Identity and Reference Types in SQL - Implementing O-R Features - Persistent Programming Languages - Object-Relational Mapping. Object- Oriented Databases: Motivation – Concepts and Features – Object Modelling – Indexing – Design Considerations- Object-Oriented versus Object-Relational. XML Databases: Motivation - Structure of XML Data - XML Document Schema - Querying and Transformation – XPath – XQuery – XSLT - Application Program Interfaces to XML - Storage of XML Data - XML Applications.
4. Spatial and Temporal Data: Motivation - Time in Databases - Spatial and Geographic Data - Multimedia Databases -Mobility and Personal Databases - Active Databases, Time series Databases. Advanced Transaction Processing : Transaction-Processing Monitors - Transactional Workflows - E-Commerce - Main-Memory Databases - Real-Time Transaction Systems - Long- Duration Transactions.
5. Classification of NoSQL Database Management Systems, Key-Value Stores- Document Stores- Wide-Column Stores - Graph-Oriented Databases–Redis, MongoDB, Cassandra, Neo4j – Hadoop data storage–Pig, Hive, HBase – Introduction to Integrated Data Architecture.
Cloud Databases: Database as a service (DBaS), Amazon SimpleDB, DynamoDB – EnterpriseDB - Google Cloud SQL, Google BigQuery – Microsoft Azure SQL.

References

1. A. Hoffer Jeffrey, V. Ramesh, Topi Heikki, Modern database management, 12e, Pearson, 2015.
2. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, Database System Concepts, 6e,McGraw- Hill, 2013
3. SherifSakr, Big Data 2.0 Processing Systems: A Survey, 1e, Springer: Briefs in Computer Science, 2016
4. Lee Chao, Cloud Database Development and Management, 1e, CRC Press, 2013
5. Rini Chakrabarti and Shilbhadra Dasgupta, Advanced Database Management System, 1e, Dreamtech Press, 2011

24-502-0301: Elective - MOOC

Core/Elective: **Elective**

Semester: **3**

Credits: **2**

Course Description

A credit-based MOOC course of minimum 12 weeks duration or three non-credit based MOOC courses of 4-weeks duration from SWAYAM/NPTEL/any other platforms approved by the Department Council.

24-502-0302: Internship

Core/Elective: **Core**

Semester: **3**

Credits: **1**

Course Description

A minimum 1 month internship from the institute/industry approved by the Department council. Internship should be completed during the May-June summer vacation.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Develop a holistic understanding and practical skills for professional and academic success. | Apply |
| CO2 | Demonstrate enhanced capabilities in problem-solving, effective communication, entrepreneurial thinking, and advanced subject mastery. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 |

24-502-0303: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: 3

Credits: 15

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the first part of the work, the student shall submit an interim dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva- voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in-depth knowledge and thoughtful application through the detailed analysis of the chosen research problem. | Analyze |
| CO2 | Assesses the gap in knowledge by acquiring knowledge about previous works, their interpretation, and application. | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Apply |
| CO4 | Organizes the interim dissertation content with proper structure and sequencing. | Apply |
| CO5 | Demonstrates academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | 3 | 3 | - | 3 | - |
| CO2 | 3 | - | - | 3 | 1 | - | 2 | - |
| CO3 | 3 | - | - | 3 | 2 | - | 3 | - |
| CO4 | - | 3 | - | - | 2 | - | 2 | - |
| CO5 | - | 3 | - | - | 2 | 3 | 3 | 3 |

23-502-0401: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: **4**

Credits: **17**

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the work, the student shall submit a final dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva-voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in-depth knowledge and thoughtful application through the detailed analysis of the problem chosen for the study | Analyze |
| CO2 | Assesses the gap by acquiring knowledge about the previous works, and its interpretation and application | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Apply |
| CO4 | Organize the interim dissertation content with proper structure and sequencing | Apply |
| CO5 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Evaluate |
| CO6 | Show ability to evaluate and reflect on critical questions. | Evaluate |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | 3 | 3 | 3 | - | - | 3 |
| CO2 | 3 | - | 3 | 3 | 3 | - | - | 3 |
| CO3 | 3 | - | - | 3 | 3 | - | - | 3 |
| CO4 | - | 3 | - | - | 3 | - | - | 3 |
| CO5 | - | 3 | - | - | 3 | - | - | 3 |
| CO6 | 3 | - | - | - | 3 | - | - | 3 |

Learning Outcomes and Assessment

Each course's learning outcomes will be assessed based on one or many methods, including the internal written tests, quizzes, presentations, seminars, assignments in the form of lab exercises, and group projects. The above assessment methods will be attentively created to support the intended learning outcomes that have been set out for a particular course. The program outcome attainment is measured using the CO/PO mappings.

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY



DEPARTMENT OF COMPUTER SCIENCE

PROGRAMME STRUCTURE & SYLLABUS [2025 ADMISSIONS ONWARDS]

M.TECH COMPUTER SCIENCE & ENGINEERING (DATA SCIENCE & ARTIFICIAL INTELLIGENCE) (Part-Time)

Program Outcomes (PO) For M.Tech. Computer Science & Engineering (Data Science & Artificial Intelligence) (Part-Time)

After the completion of M.Tech. programme, the students will be able to:

- PO1: Elicit deeper and current knowledge through research/exploration leading to development work with a motivation to solve practical problems.
- PO2: Communicate effectively through well-written technical documentation as well as audio-visual Presentations.
- PO3: Recognize the importance of entrepreneurship and innovation to create value and health.
- PO4: Acquire mastery in the topic of study at an exceedingly higher level.

Program Specific Outcomes (PSO) For M.Tech. Computer Science & Engineering (Data Science & Artificial Intelligence) (Part-Time)

After the completion of M.Tech. programme, the students will be able to:

- PSO1: Attain comprehensive understanding of advanced theories and models in Computer Science, Data Science and Artificial Intelligence.
- PSO2: Design, implement, and evaluate AI models and systems for real-world applications in diverse domains
- PSO3: Realize data science pipeline by integrating data engineering, analytics, and visualization for enterprise solutions
- PSO4: Enhance research skills and conduct independent research, which could lead to technological innovations and improvements in the field of AI and Data Science

| DEPARTMENT OF COMPUTER SCIENCE PROGRAMME STRUCTURE AND SYLLABUS (2025 ADMISSIONS) | | | | | | | | |
|---|-------------|--|-----------------|-------------------|-----|----------|-----|------------|
| M.TECH COMPUTER SCIENCE & ENGINEERING (DATA SCIENCE & ARTIFICIAL INTELLIGENCE) [Part-Time] | | | | | | | | |
| Semester - I | | | | | | | | |
| Sl. No. | Course code | Course Title | Core / Elective | Credits | Lec | Tutorial | Lab | Marks |
| 1 | 24-475-0101 | Probability and Statistics for Data Science | C | 4 | 4 | 2 | 2 | 100 |
| 2 | 24-475-0102 | Artificial Intelligence and Machine Learning | C | 4 | 4 | 2 | 2 | 100 |
| 3 | 24-475-0103 | Elective I | E | 2 | 0 | 0 | 2 | 100 |
| 4 | 24-475-0104 | Seminar | C | 2 | 0 | 0 | 3 | 100 |
| 5 | 24-475-0105 | Artificial Intelligence Lab | C | 2 | 0 | 0 | 4 | 100 |
| Total for Semester I | | | | 14 | 8 | 4 | 13 | 500 |
| Semester - II | | | | | | | | |
| 1 | 24-475-0201 | Applied Data Science | C | 4 | 4 | 2 | 2 | 100 |
| 2 | 24-475-0202 | Deep Learning | C | 4 | 4 | 2 | 2 | 100 |
| 3 | 24-475-0203 | Elective II | E | 2 | 0 | 0 | 2 | 100 |
| 4 | 24-475-0204 | Elective III | E | 2 | 0 | 0 | 2 | 100 |
| 5 | 24-475-0205 | Data Science Lab | C | 2 | 0 | 0 | 4 | 100 |
| Total for Semester II | | | | 14 | 8 | 4 | 12 | 500 |
| Semester - III | | | | | | | | |
| 1 | 24-475-0301 | Elective IV | E | 2 | 0 | 0 | 2 | 100 |
| 2 | 24-475-0302 | Elective V | E | 2 | 0 | 0 | 2 | 100 |
| 3 | 24-475-0303 | Dissertation & Viva Voce | C | 18 | 0 | 0 | 20 | 100 |
| Total for Semester III | | | | 22 | 0 | 0 | 24 | 300 |
| Semester - IV | | | | | | | | |
| 1 | 24-475-0401 | Dissertation & Viva Voce | C | 22 | 0 | 0 | 30 | 100 |
| Total for Semester IV | | | | 22 | 0 | 0 | 30 | 100 |
| Total credits for Degree: 72 | | | | Total Marks: 1400 | | | | |

Electives I - V can be either an approved MOOC course or a course offered by the department and shall be decided by the Department Council (DC).

24-475-0101 Mathematics for Computing

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

This course introduces the study of mathematical structures that are fundamentally discrete in nature. The course is intended to cover the main aspects that are useful in studying, describing, and modeling objects and problems in the context of Linear Algebra, computer algorithms, and programming languages.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Analyze the different methods for proving the correctness of theorems and problems. | Analyze |
| CO2 | Understand and apply the basic concepts of Linear Algebra. | Apply |
| CO3 | Understand and apply the basic aspects of Descriptive statistics. | Apply |
| CO4 | Understand and apply the fundamentals of probability theory. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 3 | - | 2 |
| CO2 | 3 | 3 | - | - | 2 | 2 | - | 2 |
| CO3 | 3 | 3 | - | - | 2 | 2 | - | 2 |
| CO4 | 3 | 3 | - | - | 3 | 2 | - | 2 |

Course Content

1. Introduction – proofs – propositions – predicates and quantifiers – truth tables – first order logic – satisfiability – pattern of proof – proofs by cases – proof of an implication – proof by contradiction – proving iff – sets – proving set equations – Russell’s paradox – well-ordering principle – induction – invariants – strong induction – structural induction
2. Vectors-Coordinate system-vector addition-vector multiplication-Linear combinations, span, and basis vectors-Matrix multiplication as composition-Three-dimensional linear transformations-The determinant-Inverse matrices, column space and null space- Nonsquare matrices as transformations between dimensions-Dot products and duality-Cross products-Cross products in the light of linear transformations-Cramer's rule-Change of basis-Eigenvectors and eigenvalues-vector spaces
3. Descriptive statistics: histogram, sample mean and variance, order statistics, sample covariance, sample covariance matrix – Frequentist statistics: sampling, mean square error, consistency, confidence intervals, parametric and non-parametric model estimation

4. Probability theory: probability spaces, conditional probability, independence – Random variables: discrete and continuous random variables, functions of random variables, generating random variables – Multivariate random variables: joint distributions, independence, generating multivariate random variables, rejection sampling – Expectation: Mean, variance and covariance, conditional expectation
5. Random process: definition, mean and autocovariance functions, iid sequences, Gaussian and Poisson process , random walk – Convergence of random process: types of convergence, law of large numbers, Central limit theorem, monte carlo simulation – Markov chains: recurrence, periodicity, convergence, markov-chain monte carlo- Gibbs sampling, EM algorithm, variational inference

References

1. Bronson, R., Costa, G.B., Saccoman, J.T. and Gross, D., Linear algebra: algorithms, applications, and techniques. 4e, 2023.
2. Eric Lehman, F Thomson Leighton, Albert R Meyer, Mathematics for Computer Science, 1e, MIT, 2010.
3. Susanna S. Epp, Discrete Mathematics with Applications, 4e, Brooks Cole, 2010.
4. Gary Chartrand, Ping Zhang, A First Course in Graph Theory, 1e, Dover Publications, 2012. in
5. John Tsitsiklis. 6.041SC Probabilistic Systems Analysis and Applied Probability. Fall 2013. Massachusetts Institute of Technology: MIT OpenCourseWare. <https://ocw.mit.edu>
6. Albert Meyer. 6.844 Computability Theory of and with Scheme. Spring 2003. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>.
7. Michael Mitzenmacher and Eli Upfal; Probability and Computing, 2ed, Cambridge University Press, 2017

Online Resources: Course notes of Carlos Fernandez-Granda, DS-GA 1002: Probability and Statistics for Data Science https://cims.nyu.edu/~cfgranda/pages/DSGA1002_fall17/index.html

24-475-0102: Artificial Intelligence and Machine Learning

Core/Elective: **Core**

Semester: **1**

Credits: **4**

Course Description

Machine learning is programming computers to optimize a performance criterion using example data or past experience. This course is to discuss many methods that have their bases in different fields: statistics, pattern recognition, neural networks, artificial intelligence, signal processing, control, and data mining. Major focus of the course is on the algorithms of machine learning to help students to get a handle on the ideas, and to master the relevant mathematics and statistics as well as the necessary programming and experimentation.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Levels |
|-----|--|------------------|
| CO1 | Understand and explain the different types of the learning process, and key ethical considerations. | Understand |
| CO2 | Learn to effectively prepare data for machine learning models through data cleaning, feature selection, and dimensionality reduction. | Apply |
| CO3 | Implement and interpret linear and non-linear regression models, while comparing various classification techniques including tree-based, kernel, and ensemble methods. | Apply |
| CO4 | Gain practical knowledge in identifying data clusters using various algorithms and discovering hidden patterns through association rule learning. | Apply |
| CO5 | Understand the basic building blocks of neural networks, implement the backpropagation algorithm, and explore the concept of MDPs and Q-learning. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 3 | 1 | 1 | 2 |
| CO2 | 3 | - | - | - | 3 | 1 | 1 | 2 |
| CO3 | 3 | - | - | 3 | 3 | 1 | 3 | 2 |
| CO4 | 3 | - | - | 3 | 3 | 1 | 2 | 2 |
| CO5 | 3 | - | - | 3 | 3 | 1 | 3 | 2 |

Course Content

1. Introduction to AI - What is AI? A Brief History of AI - Different types of AI - Applications of AI -

Problem Solving Methods – Heuristics. Knowledge Representation and Reasoning - Planning and Decision-Making: Ethics and Societal Impact of AI.

2. Machine Learning Fundamentals - Concept of Machine Learning: Definition, applications, types of learning (supervised, unsupervised, reinforcement) - Hypothesis Spaces and Inductive Bias - Learning Process - Machine Learning Ethics and Bias. Data Preprocessing and Feature Engineering: Data Representation - Data Preprocessing - Features and Types - Dimensionality Reduction – Feature Identification - Feature selection – Feature extraction - Feature Importance-High dimensional data and Manifolds.
3. Regression and Classification - Regression: Linear Regression – Non-Linear regression – evaluation metrics for regression– Classification: Binary, multi-class, and multi-label classification – lazy learners - tree-based techniques - kernel-based techniques - probabilistic techniques - and ensembled techniques – evaluation metrics for classification.
4. Clustering and Rule Mining - Clustering: Partitioning based – hierarchical based – density based– grid-based – model based - Rule mining: Apriori algorithm, FB Growth - association rules. Outlier Detection - LOF.
5. Artificial Neural Networks and Reinforcement Learning -Neural Networks: McCulloch-Pitts neurons, Hebb’s networks, Hopfield networks, Boltzmann machines, Perceptrons, multilayer perceptrons, backpropagation. Reinforcement Learning: Markov Decision Processes (MDPs), Q-learning.

References

1. Ethem Alpaydin, Introduction to Machine Learning, 3e, MIT Press, 2014
2. Tom M. Mitchell, Machine Learning, McGraw Hill Education; 1e, 2017
3. Stephen Marsland, Machine Learning, An Algorithmic Perspective, 2e, CRC Press, 2015
4. Giuseppe Bonaccorso, Machine Learning Algorithms, 1e, Packt Publishing Limited, 2017
5. Ethem Alpaydin, Machine Learning- The New AI, MIT Press, 1e, 2016
6. Andrew Ng, Machine Learning Yearning, ATG AI (Draft version), 1e, 2018
7. Rohit Singh, Tommi Jaakkola, and Ali Mohammad.6.867 *Machine Learning*. Fall 2006. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>
Andrew Ng, <https://www.coursera.org/learn/machine-learning>

24-475-0104: Seminar

Core/Elective: **Core**

Semester: **1**

Credits: **2**

Course Description

The student has to prepare and deliver a presentation on a research topic suggested by the department before the peer students and staff. They also have to prepare a comprehensive report of the seminar presented.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Find out relevant information for the topic. | Understand |
| CO2 | Define clearly the topic for discussion. | Understand |
| CO3 | Deliver the content effectively. | Apply |
| CO4 | Organize the content with proper structure and sequencing. | Apply |
| CO5 | Demonstrate the academic discussion skills to emphasize, and argue with clarity of purpose using evidence for the claims. | Analyze |
| CO6 | Show the ability to evaluate and reflect on critical questions. | Analyze |
| CO7 | Show attempts to reach across diverse disciplines and bring other schools of thought into the discussions. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | 1 | - | - | 3 | 1 | - | - |
| CO2 | 3 | - | - | - | 2 | 1 | - | - |
| CO3 | | 3 | - | - | 2 | 3 | - | 1 |
| CO4 | 1 | 2 | - | - | 1 | - | - | - |
| CO5 | 2 | 3 | - | - | 3 | 1 | 1 | 1 |
| CO6 | 2 | - | - | 3 | 3 | 2 | 3 | 1 |
| CO7 | 2 | - | - | 3 | 3 | - | 1 | 1 |

Course Description

The course aims to give valuable hands-on experience in designing, implementing, and evaluating AI solutions. Whether pursuing further study or entering the workforce, graduates of the AI Lab course will be well-equipped to tackle the challenges and opportunities presented by the rapidly evolving field of Artificial Intelligence.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Become familiar with AI tools used in the industry and academic research | Understand |
| CO2 | Apply machine learning concepts to real-world problems and tune parameters for best results. | Apply |
| CO3 | Implement AI algorithms for a better understanding of the latest developments in this field. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | - | 2 | - | 3 | 2 | 2 | 1 |
| CO2 | 2 | - | - | - | 3 | 2 | 2 | 1 |
| CO3 | 3 | - | - | 2 | 3 | 2 | 2 | 1 |

Course Content

1. Write a program to solve n-Queens problem in AI
2. Write a program to solve BFS search in AI
3. Write a program to solve DFS search in AI
4. Write a program to implement Local Search using Hill climbing with random neighbor
5. Write a program to solve A* Search in AI
6. Write a program to solve AO* Search in AI
7. Write a program to implement alpha beta pruning
8. Write a program to solve Water jug problem in AI.
9. Implement different supervised learning models and evaluate its performance.
10. Implement different unsupervised learning models and evaluate its performance.
11. Implement the different model optimization techniques.

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description

This applied data science course empowers you to transform diverse data sets into valuable insights that solve real-world problems. Embark on a journey through the complete data science lifecycle, mastering each step from identifying questions to crafting impactful stories with your findings. Gain hands-on experience with cutting-edge techniques while developing the ethical compass to use data responsibly across various industries.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|---|-----------------|
| CO1 | Navigate the Data Science Landscape: Grasp applications across industries, master the data science lifecycle. | Apply |
| CO2 | Master Data Preparation & Engineering: Implement warehousing concepts, build efficient data pipelines, and ensure data quality. | Apply |
| CO3 | Analyze Data with Confidence: Utilize descriptive statistics, hypothesis testing, regression models, classification algorithms, and clustering techniques for insightful analysis. | Analyze |
| CO4 | Craft Compelling Data Visualizations: Design effective visuals using best practices and popular tools, and create impactful narratives to communicate findings. | Apply |
| CO5 | Embrace DataOps & Big Data Technologies: Understand DataOps automation, implement CI/CD practices, explore big data technologies like Hadoop, Spark, and Kafka, and analyze challenges and opportunities presented by big data. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | - | - | - | 2 | 2 | 2 | - |
| CO2 | 2 | - | - | 3 | 2 | 3 | 3 | - |
| CO3 | 2 | - | - | 3 | 2 | 2 | 1 | 1 |
| CO4 | 2 | 3 | - | 1 | 2 | - | - | - |
| CO5 | 3 | 1 | - | 2 | 2 | 2 | 1 | 1 |

Course Content:

1. Introduction to Applied Data Science - Overview of the data science landscape and its applications in various industries- The data science lifecycle: problem identification, data collection, data cleaning and preprocessing, analysis, modeling, and communication.- Ethical considerations in data science.
2. Data Warehousing and Engineering - Introduction to data warehousing concepts: dimensional modeling, star schemas, snowflake schemas, data marts. Data warehousing technologies: relational databases, data warehouses, data lakes.Data engineering: data extraction, transformation, and loading (ETL) processes, data pipelines, data quality management.
3. Data Analytics - Descriptive statistics: measures of central tendency, measures of dispersion, measures of association.-Inferential statistics: hypothesis testing, confidence intervals.- Regression analysis: simple linear regression, multiple linear regression- Classification: decision trees, random forests, support vector machines.-Clustering: k-means clustering, hierarchical clustering.
4. Data Visualization - Principles of data visualization: selecting the right chart type, using color effectively, labeling charts clearly. Tools for data visualization: Tableau, Power BI, matplotlib, seaborn. Storytelling with data visualization: how to create visual narratives that communicate insights effectively.
5. DataOps and Big Data- Introduction to DataOps: automating the data pipeline, continuous integration and continuous deployment (CI/CD), monitoring and alerting- Big data technologies: Hadoop, Spark, Kafka.- Challenges and opportunities of big data.

References

1. Applied Data Science with Python and Jupyter: Use powerful industry-standard tools to unlock new, actionable insights from your data; Alex Galea (2018); Packt Publishing. ISBN: 9781789951929.
2. Applied Data Science - Lessons Learned for the Data-Driven Business; Braschler, Stadelmann, Stockinger (Eds.); Springer(2019).
3. <https://em360tech.com/sites/default/files/2020-08/DataOps%20Cookbook%202nd%20Edition%20FINAL.pdf>
4. Data Warehousing and Analytics: Fueling the Data Engine; David Taniar, Wenny Rahayu;Springer Cham(2022); <https://doi.org/10.1007/978-3-030-81979-8>

24-475-0202: Deep Learning

Core/Elective: **Core**

Semester: **2**

Credits: **4**

Course Description:

Deep learning is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. This course describes deep learning techniques used by practitioners in industry, including deep feedforward networks, regularization, optimization algorithms, convolutional networks, sequence modeling, and practical methodology. This course is useful to students planning careers in either industry or research, and for software engineers who want to begin using deep learning in their products or platforms

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Understand the need for Deep learning, Feed-forward networks, Learning XOR, Gradient-based Learning, and Hidden units. | Understand |
| CO2 | Differentiate between training error and generalization error, Underfitting and Overfitting. And Identify Regularization strategies, Dataset Augmentation, and Adversarial Training. | Analyze |
| CO3 | Describe the working of Convolution Operation, Sparse interactions, Parameter sharing, Equivariant representations, Pooling and Recurrent Neural Networks | Understand |
| CO4 | Understand different types of Autoencoders, Undercomplete Autoencoders, Regularized Autoencoders, Dimensionality Reduction. | Understand |
| CO5 | Explain Deep generative models like Boltzmann Machines, Restricted Boltzmann Machines. | Understand |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | 1 | - | 2 | 3 | - | - | - |
| CO2 | 1 | - | - | 1 | 2 | 1 | 1 | - |
| CO3 | 2 | 1 | - | 2 | 3 | 2 | 2 | 1 |
| CO4 | 1 | - | - | 1 | 3 | 2 | 2 | - |
| CO5 | 2 | 1 | - | 2 | 2 | 2 | 2 | 1 |

Course Content:

1. Deep Networks: Feed forward networks – Learning XOR- Gradient based Learning – Hidden units – Architecture design- Back propagation – Differentiation algorithms
2. Regularization for Deep Learning: Penalties-Constrained optimization-Under constrained problems- Dataset augmentation-Semi Supervised learning- Sparse representation- Adversarial training- Optimization for training deep models: Basic algorithms-Algorithms with adaptive learning rates
3. Convolutional Networks: Convolution-Pooling-Variants of pooling- Efficient convolutional algorithms – Recurrent and Recursive Nets: Recurrent Neural Networks- Deep Recurrent Networks- Recursive Neural Networks- Explicit memory
4. Linear Factor Models: Probabilistic PCA- ICA – Slow feature analysis – Sparse coding – Autoencoders: Undercomplete Autoencoders – Regularized Autoencoders- Learning Manifolds- Applications of Autoencoders – Representation learning
5. Deep generative models: Boltzmann Machines – RBM- Deep Belief Networks-Deep Boltzmann Machines-Convolutional Boltzmann Machines- Directed generative Nets

References

1. Nithin Buduma, Nikhil Buduma and Joe Papa, Fundamentals of Deep Learning, 2nd Edition, O'Reilly, 2022
2. Jon Krohn and Grant Beyleveld, Deep learning Illustrated, Addison-Wesley; 1st edition, 2019
3. M Gopal, Deep Learning, Pearson Education; 1st edition, 2022
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 1e, MIT Press, 2016
5. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, 1e, Shroff/O'Reilly, 2017

24-475-0205: Data Science Lab

Core/Elective: **Core**

Semester: 2

Credits: 2

Course Description

This applied data science course empowers you to transform diverse data sets into valuable insights that solve real-world problems. Embark on a journey through the complete data science lifecycle, mastering each step from identifying questions to crafting impactful stories with your findings. Gain hands-on experience with cutting-edge techniques while developing the ethical compass to use data responsibly across various industries.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Learn about software tools used in the field of data science. | Understand |
| CO2 | Apply data science principles in practical situations to produce insights by processing data | Apply |
| CO3 | Visualize insights in a manner conducive for decision-making. | Apply |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3 | - | - | - | 2 | - | - | - |
| CO2 | - | - | - | 3 | 3 | - | 2 | - |
| CO3 | - | 2 | 1 | - | - | 2 | - | - |

Course Content:

Lab cycle 1

1. Download, install and explore the features of NumPy, SciPy, Jupyter, and Pandas packages.
2. Working with Numpy arrays
3. Working with Pandas data frames
4. Reading data from text files, Excel and the web and exploring various commands for doing descriptive analytics on the Iris data set
5. We want to investigate the behavior of the total positive COVID-19 cases weekly from 22 January 2020 to 15 December 2020 in India. Perform the following tasks:

Data set link <https://raw.githubusercontent.com/datasets/covid-19/master/data/time-series-19->

[covid-combined.csv](#)

- a. Univariate Time Series Analysis:
 - i. Create a time series object for the total positive COVID-19 cases
 - ii. Visualize the time series data using a line chart.
- b. Multivariate Time Series Analysis:
 - i. Also, consider the **total deaths** from COVID-19 during the same period.
 - ii. Create a multivariate time series object that includes both the total positive case and total deaths.
 - iii. Plot both series on a single chart.
- c. Time Series Forecasting:
 - i. Forecast the next 5 data points.
 - ii. Plot the forecasted values.

Lab Cycle 2 – Data visualisation

1. Create a scatterplot of the Sepal.Length and Petal.Length variables in the iris dataset using the plot function? Add appropriate labels and title to the plot. Save the plot as a high-resolution image file.
2. Create a scatterplot of the mpg and disp variables in the mtcars dataset. Use different colors to represent the cyl variable and add a smooth line to show the trend. Add appropriate labels, title, and legend to the plot
3. Create a bar plot of the number of cylinders (cyl) in the mtcars dataset. Use different colors to represent the transmission type (am). Add appropriate title, labels, and legend to the plot.
4. Create a histogram of the miles per gallon (mpg) in the mtcars dataset. Use different shades of blue to represent the frequency of each bin. Add appropriate title and labels to the plot. Calculate and display the mean and standard deviation of mpg on the plot.
5. Create a box plot of the horsepower (hp) in the mtcars dataset. Use different shapes to represent the number of gears (gear). Add appropriate title, labels, and legend to the plot. Identify and label any outliers on the plot.
6. Create a time series plot using real-world data.
(<https://www.kaggle.com/datasets/niketchauhan/covid-19-time-series-data>)

Lab cycle 3 – Exploratory Data Analysis and Regression

1. Perform EDA on "Titanic Dataset". You are given the Titanic dataset, which contains information about passengers on the Titanic, including their survival status, age, class, and gender.
 - a) plot the histogram of Number of parents and children of the passenger aboard(parch).
 - b) Perform a detailed EDA, including advanced statistical analysis, to explore factors influencing survival rates.
 - c) Create a customized box plot to visualize the age distribution of survivors and non-survivors.

2. EDA on "Iris Dataset"
 - a. For the Iris dataset, which contains measurements of various iris flowers, conduct an EDA.
 - b. Determine if there are statistically significant differences in sepal lengths between different species using a suitable statistical test.
 - c. Create a pair plot to visualize the relationships between all variables.
3. Suppose you have a dataset containing information about house prices (dependent variable, denoted as price) and the size of the houses (in square feet, independent variable, denoted as size). You want to build a linear regression model to predict house prices based on their size.
 - a. Load the dataset <https://www.kaggle.com/competitions/house-prices-advanced-regression-techniques>
 3. Fit a simple linear regression model with price as the dependent variable and size as the independent variable.
 4. Calculate the regression coefficients (slope and intercept).
 5. Plot the regression line along with the scatter plot of the data points.

24-475-0303: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: **3**

Credits: **18**

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the work, the student shall submit a final dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva-voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in depth knowledge and thoughtful application through the detailed analysis of the problem chosen for the study | Analyze |
| CO2 | Assess the gap by acquiring knowledge about the previous works, and its interpretation and application | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Analyze |
| CO4 | Organize the interim dissertation content with proper structure and sequencing | Apply |
| CO5 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Analyze |
| CO6 | Show ability to evaluate and reflect on critical questions. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | | 1 | 2 | 2 | - | - | - |
| CO2 | 2 | - | 1 | 2 | 1 | 1 | 1 | - |
| CO3 | 2 | - | - | 2 | 2 | 1 | - | 1 |
| CO4 | - | 2 | - | 1 | 1 | - | - | - |
| CO5 | - | 3 | - | 2 | 2 | 2 | 1 | 1 |
| CO6 | 2 | - | - | 2 | 2 | 2 | | 2 |

24-475-0401: Dissertation & Viva Voce

Core/Elective: **Core**

Semester: **4**

Credits: **22**

Course Description

The dissertation work spans two semesters. Through the dissertation work, the student has to exhibit the knowledge in terms of engineering or technological innovation or research ability to solve the contemporary problem. On completion of the work, the student shall submit a final dissertation report. The qualitative and quantitative results of the work will be evaluated through a viva-voce exam.

Course Outcomes (CO)

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

| CO | Course Outcome Statement | Cognitive Level |
|-----|--|-----------------|
| CO1 | Demonstrates in depth knowledge and thoughtful application through the detailed analysis of the problem chosen for the study | Analyze |
| CO2 | Assess the gap by acquiring knowledge about the previous works, and its interpretation and application | Analyze |
| CO3 | Demonstrates the design of the proposed methodology and its merits. | Analyze |
| CO4 | Organize the interim dissertation content with proper structure and sequencing | Apply |
| CO5 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | Analyze |
| CO6 | Show ability to evaluate and reflect on critical questions. | Analyze |

Mapping with Program Outcomes

| | PO1 | PO2 | PO3 | PO4 | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2 | | 1 | 2 | 2 | - | - | - |
| CO2 | 2 | - | 1 | 2 | 1 | 1 | 1 | - |
| CO3 | 2 | - | - | 2 | 2 | 1 | - | 1 |
| CO4 | - | 2 | - | 1 | 1 | - | - | - |
| CO5 | - | 3 | - | 2 | 2 | 2 | 1 | 1 |
| CO6 | 2 | - | - | 2 | 2 | 2 | | 2 |

**DEPARTMENT OF COMPUTER SCIENCE
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY**



**PROGRAMME STRUCTURE & SYLLABUS
[2024 ADMISSIONS ONWARDS]**

**Five Year Integrated M.Sc. in Computer Science
(Artificial Intelligence & Data Science)**

Vision

- ❖ To globally excel in innovative research, teaching, and technology development inspired by social obligation.

Mission

- ❖ To contribute to knowledge development and dissemination.
- ❖ To facilitate learning and innovative research in frontier areas of computer science.
- ❖ To drive students for technology development to solve problems of interest.
- ❖ To create socially responsible professionals.

Program Outcomes: Integrated M.Sc.

PO1: Demonstrate a comprehensive understanding of fundamental principles and concepts in basic sciences.

PO2: Analyze, evaluate, and synthesize complex scientific information and data using appropriate methods and techniques.

PO3: Apply scientific reasoning and critical thinking adeptly to recognize, assess, and resolve problems encountered in various scientific contexts.

PO4: Utilize computational power, programming languages, and modern technologies proficiently to address scientific challenges, effectively integrating technological solutions into problem-solving processes.

PO5: Communicate scientific information effectively and demonstrate proficiency in the use of modern scientific tools and technologies for experimentation, data collection, analysis, and interpretation.

PO6: Adhere to ethical principles and practices in the conduct of scientific research and professional activities, and work collaboratively with others.

PO7: Engage in lifelong learning and professional development to enhance the knowledge and skills in basic sciences.

Programme Specific Outcomes

After the completion of Five Year Integrated M.Sc. in Computer Science (Artificial Intelligence & Data Science) programme, the students will have:

PSO 1: Deep understanding and proficiency in advanced topics such as Algorithms, Software Engineering, Artificial Intelligence and Data Science

PSO 2: Training in research methodologies, experimental design, and critical analysis to contribute to the advancement of computer science through original research

PSO 3: Specialization opportunities in areas such as Computer Vision, Natural Language Processing, Bioinformatics, Software Engineering, Cyber Security, and Cyber Physical Systems based on personal interests and career goals

PSO 4: Understanding the ethical implications of technology and the responsibility of computer scientists to develop and use technology in an ethical and society responsible way.

I. Academic programme pathways offered by the Department of Computer Science

A. Computer Science (Artificial Intelligence & Data Science) Major

1. **3-year UG Programme:** B.Sc. in Computer Science will be awarded to those who complete a three-year degree programme securing a minimum of 133 credits, out of which a minimum of 68 credits should be from Computer Science discipline and have satisfied the minimum course requirements as mentioned in Table No 1.
2. **4-year UG Programme (Honours with Research): B.Sc. (Honours with Research) in Computer Science (Artificial Intelligence & Data Science)** will be awarded to those who complete a four-year degree programme securing a minimum of 177 credits, out of which a minimum of 104 credits(including 12 credits Research Project) should be from Computer Science (Artificial Intelligence & Data Science) discipline and have satisfied the minimum course requirements as mentioned in Table No 1 and 2.
3. **4-year UG Programme (Honours): B.Sc. (Honours) in Computer Science (Artificial Intelligence & Data Science)** will be awarded to those who complete a four-year degree programme securing a minimum of 177 credits, out of which a minimum of 104 credits should be from Computer Science (Artificial Intelligence & Data Science) discipline and have satisfied the minimum course requirements as given in Table No 1 and 2.
4. **5-year Integrated PG Degree : Five Year Integrated M.Sc. in Computer Science (Artificial Intelligence & Data Science)** will be awarded to those who complete a five-year degree programme securing a minimum of 221 credits out of which a minimum of 148 credits should be from Computer Science (Artificial Intelligence & Data Science) discipline and have satisfied the minimum course requirements as given in Table No 1,2 and 3.

B. Minor Degree in Computer Science

1. **3-year UG Programme:** Minor Degree in Computer Science will be awarded to those who complete a three-year degree programme in any of the discipline mentioned in the FYUGP regulations and completed a minimum of 27 credits in Computer Science, out of

which 24 credits should be from CS Minor-DSC courses and 03 credits from a Skill Enhancement Course -CS SEC

2. **4-year UG Programme:** Minor Degree in Computer Science will be awarded to those who complete a four-year degree programme in any of the discipline mentioned in the FYUGP regulations and completed a minimum of 35 credits in Computer Science, out of which 32 credits should be from CS Minor DSC courses and 03 credits from a CS Skill Enhancement Course-CS SEC

C. Discipline mention in Computer Science:

A Discipline mention in Computer Science will be awarded to those who complete a three year or four-year degree programme in any of the discipline mentioned in the FYUGP regulations and completed a minimum of 12 credits in Computer Science DSC Course in the first three years of the programme.

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**Five Year Integrated M.Sc. in
Computer Science
(Artificial Intelligence & Data Science)
Scheme (2024 Admission onwards)**

Table 1 : Semester 1 to 6 Scheme for the Five Year Integrated M.Sc. in Computer Science (Artificial Intelligence & Data Science) 2024 Admission onwards

| Semester | Computer Science Major | Computer Science Minor | Foundation Courses | | | | Total credits |
|----------------------------------|---|------------------------|--------------------|-------------------|--------------|--------------|---------------|
| | MDC* 3 credits | AEC* 3 credits | SEC 3 credits | VAC* 3 credits | | | |
| I | 1 | 2 | 1 | 2* | | | 21 |
| II | 1 | 2 | 1 | 2* | | | 21 |
| III | 1 | 2 | 1 | | | 2* | 21 |
| IV | 4 | | | | 1 | 1* | 22 |
| V | 5 | | | | 1 | | 23 |
| VI | 5 (Out of the five courses one course is a 4 credit Mini Project) | | | | 1 | | 23 |
| | | Internship** | | | | | 2 |
| Total credits(co courses) | 68 (17) | 24 (6) | 9 (3) | 12 (4) | 9 (3) | 9 (3) | 133 |

*Courses offered commonly to all Integrated M.Sc. programme at University Level

**Not counted as a course

Minor Degree in Computer Science: Total Credits required= 27 [24 credits should be from CS Minor-DSC courses and 03 credits from a CS Skill Enhancement Course(CS SEC)]

Exit option 1(Major Degree): B.Sc. in Computer Science (Total credit requirements = 133)

**Table 2 : Semester 7 and 8 Scheme for the Five Year Integrated M.Sc. in Computer Science
(Artificial Intelligence & Data Science) 2024 Admission onwards**

| Semester | Computer Science Major 4 credits | Seminar 2 credits | Laboratory 2 credits | Mini Project | Elective 4 Credits | Computer Science Minor 4 credits | Foundation Courses | Total Credits | |
|--|-------------------------------------|---|-------------------------|--------------|-----------------------|-------------------------------------|--------------------|---------------|-----|
| VII | 4 | 1 | | | | 1* | | 22 | |
| VIII | B.Sc. Honors with Research** | | 1 | 12 Credits | 1 | 1* | | 22 | |
| | B.Sc. Honors | | 1 | 4 Credits | 3 | 1* | | 22 | |
| Total credits(courses) | B.Sc. Hons. (Research) ² | 80 (20) | 2(1) | 2(1) | 16(2) | 4(1) | 32(8) | 39(13) | 177 |
| | | Total Credit Requirements from Computer Science discipline =104 | | | | | | | |
| | B.Sc. Hons ¹ | 80 (20) | 2(1) | 2(1) | 8(2) | 12(3) | 32(8) | 39(13) | 177 |
| | | Total Credit Requirements from Computer Science discipline =104 Credits | | | | | | | |
| <p>*4-year UG Programme students seeking minor Degree in Computer Science must earn 8 more credits in the Fourth year.</p> <p>**Eligibility for a student to be considered for the 4-year UG Degree (Honors with Research) programme is CGPA 8.0 up to sixth semester. The number of seats and the selection criteria shall be fixed by the DCS Department Council.</p> <p>¹Exit option 2 : B.Sc. (Honours with Research) in Computer Science (Artificial Intelligence & Data Science)</p> <p>²Exit option 3: B.Sc. (Honours) in Computer Science (Artificial Intelligence & Data Science)</p> | | | | | | | | | |

**Table 3 : Semester 9 and 10 Scheme for the Five Year Integrated M.Sc. in Computer Science
(Artificial Intelligence & Data Science) 2024 Admission onwards**

| Semester | Computer Science (Artificial Intelligence & Data Science) Major | Seminar (2 credits) | Lab (2 credits) | Project | Elective 4 Credits | Computer Science Minor 4 Credits | Foundation Courses | Total credits |
|--|--|---------------------|-----------------|---|---|----------------------------------|--------------------|---------------|
| IX | | | | Project Phase I (14 Credits) | 2 | | | 22 |
| X | | | | Project Phase II (22 Credits) | | | | 22 |
| Total credits(Courses) | 80(20) | 2(1) | 2 (1) | Honours with Research 52(4) / Honours 44(4) | Honours with Research 12(3) / Honours 20(5) | 32(8) | 39 | 221 |
| | Total Credit Requirements from Computer Science discipline =148 Credits | | | | | | | |
| Five Year Integrated M.Sc. in Computer Science (Artificial Intelligence & Data Science) | | | | | | | | |

**Five Year Integrated M.Sc. in
Computer Science
(Artificial Intelligence & Data Science)
Course structure
(2024 Admission onwards)**

Semester I

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0101 | 100-199 | Computational Thinking with Python | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0102 | 100-199 | Practical Applications of AI | CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0103 | 100-199 | Computational Thinking for Problem Solving | CS MDC | 3 | 3-1-0 | 50 | 50 | 100 |
| Credit Requirements | | 21 Credits (AEC: 6 Credits, MDC: 3 Credits, Major pathway: 4, Minor pathway: 8 Credits) Cumulative credits: 21 | | | | | | |

L: Lecture, T: Tutorial, P: Practicum

CS Major-DSC: Core course for students Majoring in Computer Science

CS Minor-DSC: Core course for students Minor in Computer Science

CS Disci-DSC: Core course for students who choose discipline mention in Computer Science

CS MDC: Multidisciplinary course offered to students whose Major or Minor pathways are different from Computer Science

AEC: Ability Enhancement Course(Offered at University Level

Semester II

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|--|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0201 | 100-199 | Fundamentals of Programming | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0202 | 100-199 | Computer Fundamentals 1 | CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0203 | 100-199 | Foundations of Programming | CS MDC | 3 | 3-1-0 | 50 | 50 | 100 |
| Credit Requirements | | 21 Credits(AEC: 6, MDC: 3, Major pathway: 4, Minor pathway: 8) Cumulative credits: 42 | | | | | | |

Semester III

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0301 | 200-299 | Data Structures | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0302 | 200-299 | Computer Fundamentals II | CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0303 | 200-299 | Fundamentals of Data Structures | CS MDC | 3 | 3-1-0 | 50 | 50 | 100 |
| Credit Requirements | | 21 (VAC: 6, MDC: 3, Major pathway: 4, Minor pathway: 8) Cumulative credits: 63 | | | | | | |

Semester IV

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0401 | 200-299 | Advanced Programming with Java | CS Major -DSC | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0402 | 200-299 | Digital Logic and Computer Organization | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0403 | 200-299 | Introduction to Artificial Intelligence | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0404 | 200-299 | Database Management Systems | CS Major -DSC | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0405 | 200-299 | Python for Data Science and Machine Learning | CS SEC | 3 | 3-1-2 | 50 | 50 | 100 |
| Credit Requirements | | 22 (VAC: 3, SEC: 3, Major pathway: 16) Cumulative credits:85 | | | | | | |

Semester V

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|-----------------------------------|---|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0501 | 300-399 | Mathematics for Computing | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0502 | 300-399 | Fundamentals of Data Science | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0503 | 300-399 | Operating System | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0504 | 300-399 | Theory of Computation | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0505 | 300-399 | Design and Analysis of Algorithms | CS Major -DSC | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0506 | 200-299 | R for Data Science | CS-SEC | 3 | 3-1-2 | 50 | 50 | 100 |
| Credit Requirements | | | 23 (SEC: 3, Major pathway: 20) Cumulative credits: 108 | | | | | |

Semester VI

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---|--------------|-----------------------------|---|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0601 | 300-399 | Machine Learning | CS Major -DSC CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0602 | 300-399 | Agile Software Engineering | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0603 | 300-399 | Computer Networks | CS Major -DSC CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0604 | 300-399 | Natural Language Processing | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0605 | 300-399 | Mini Project -1 | CS Major -DSC | 4 | 0-0-4 | 50 | 50 | 100 |
| 24-813-0606 | 200-299 | Web Technologies | CS -SEC | 3 | 3-1-2 | 50 | 50 | 100 |
| Credit Requirements | | | 23 (SEC: 3, Major pathway: 20) Cumulative credits: 131 | | | | | |
| Internship(2 Credits) | | | | | | | | |
| Students have to complete an internship of 2 credits (60 Hours of work) before the beginning of Semester VII. | | | | | | | | |
| Cumulative credits: 133 | | | | | | | | |

Semester VII

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0701 | 400-499 | Deep Learning | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0702 | 300-399 | Bigdata Analytics | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0703 | 400-499 | Cloud Computing and virtualization | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0704 | 400-499 | Cyber Security | CS Major -DSC | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0705 | 300-399 | Image Processing and Computer Vision | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-2 | 50 | 50 | 100 |
| 24-813-0706 | 400-499 | Seminar | CS Major -DSC | 2 | 0-0-2 | 100 | | 100 |
| Credit Requirements | | 22 (Major pathway: 22) Cumulative credits: 155 | | | | | | |

Semester VIII(Honours with Research)

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0801 | 300-399 | Bioinformatics | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-080X | 400-499 | Elective -1 | CS Major -DSE, | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0802 | 400-499 | Research Project | CS Major -DSC | 12 | 0-0-12 | 50 | 50 | 100 |
| 24-813-0803 | 400-499 | Full Stack AI Lab | CS Major -DSC | 2 | 0-0-2 | 50 | 50 | 100 |
| Credit Requirements | | 22 (Major pathway: 22) Cumulative credits: 177 | | | | | | |

Semester VIII(Honours)

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0801 | 400-499 | Bioinformatics | CS Major -DSC, CS Minor-DSC CS Disci | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-080X | 400-499 | Elective -1 | CS Major -DSE, | 4 | 4-1-0 | 50 | 50 | 100 |
| 24-813-0809 | 400-499 | Elective -2 (MOOC*) | CS Major -DSE | 4 | 0-0-0 | | | 100 |
| 24-813-0810 | 400-499 | Elective -3 (MOOC*) | CS Major -DSE | 4 | 0-0-0 | | | 100 |
| 24-813-0811 | 400-499 | Mini Project -2 | CS Major -DSC | 4 | 0-0-0 | 50 | 50 | 100 |
| 24-813-0803 | 400-499 | Full Stack AI Lab | CS Major -DSC | 2 | 0-0-2 | 50 | 50 | 100 |
| Credit Requirements | | 22 (Major pathway: 22) Cumulative credits: 177 | | | | | | |

*A credit-based MOOC course of minimum 12 weeks duration from SWAYAM/NPTEL/CUSAT any other platforms approved by the Department. Students may be permitted to enrol MOOC courses approved by Department Council at any time during the programme and acquire the required credits before completing the programme.

List of Electives

24-813-0804 Advanced Optimization Techniques

24-813-0805 Blockchain Technology

24-813-0806 Information Retrieval and Web search

24-813-0807 Number Theory and Cryptography

24-813-0808 Large Language Models

Semester IX

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-0901 | 500-599 | Major Project Phase- I | CS Major -DSC | 14 | 0-0-14 | 50 | 50 | 100 |
| 24-813-0902 | 500-599 | Elective -4 (MOOC*) | CS Major -DSE | 4 | 0-0-0 | | | 100 |
| 24-813-0903 | 500-599 | Elective -5(MOOC*) | CS Major -DSE | 4 | 0-0-0 | | | 100 |
| Credit Requirements | | 22 (Major pathway: 22) Cumulative credits: 199 | | | | | | |

*A credit-based MOOC course of minimum 12 weeks duration from SWAYAM/NPTEL/CUSAT any other platforms approved by the Department. Students may be permitted to enrol MOOC courses approved by Department Council at any time during the programme and acquire the required credits before completing the programme.

Semester X

| Course Code | Course Level | Course Name | The course can be taken towards obtaining credits for: | Credits | Hours/week L-T-P | Marks distribution | | |
|---------------------|--------------|---|--|---------|---------------------|--------------------|-----|-------|
| | | | | | | CA | ESE | Total |
| 24-813-1001 | 600-699 | Major Project Phase- II | CS Major -DSC | 22 | 0-0-22 | 50 | 50 | 100 |
| Credit Requirements | | 22 (Major pathway: 22) Cumulative credits: 221 | | | | | | |

**Five Year Integrated M.Sc. in
Computer Science
(Artificial Intelligence & Data Science)
Syllabus (2024 Admission onwards)**

| Semester 1 | | | | | | |
|--|--|------|------|------|-------------------------|-------------------|
| 24-813-0101 | Computational Thinking with Python (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Recognizing and Defining Computational Problems | | | | | Understand |
| CO2 | Designing algorithms for simple problems using computational thinking principles | | | | | Apply |
| CO3 | Applying inductive and deductive reasoning, and Boolean logic to solve problems | | | | | Apply |
| CO4 | Designing solutions and solution processes based on problem definitions. | | | | | Apply |
| CO5 | Programming CT artifacts using Python | | | | | Analyze |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | - | - | - | | |
| CO2 | 3 | 2 | 3 | - | | |
| CO3 | 3 | 3 | 1 | - | | |
| CO4 | 1 | 3 | 3 | - | | |
| CO5 | - | 3 | 2 | - | | |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1

Elements of Computational Thinking - Understanding computational thinking - Decomposing problems, Recognizing patterns, Generalizing patterns, Designing algorithms for simple problems

Module 2

Understanding Algorithms and Algorithmic Thinking - Defining algorithms in depth, Designing algorithms, Analyzing algorithms - Big-Oh notation.

Module 3

Understanding Logical Reasoning - Inductive reasoning, Deductive reasoning. Using Boolean logic and operators. Identifying Logical Errors and Debugging. Understanding the problem definitions - Learning how to decompose problems - Converting the flowchart into an algorithm. Designing Solutions and Solution Processes

Module 4

Identifying Challenges within Solutions - Identifying errors in algorithm design - Debugging algorithms -Comparing solutions - Refining and redefining solutions

Module 5

Introduction to Python, Using Computational Thinking in Simple Challenges, Using Python in Experimental and Data Analysis Problems - Classification and Clusters, Using Computational Thinking and Python in Statistical Analysis

References

1. Applied Computational Thinking with Python - Second Edition. By Sofía De Jesús, Dayrene Martinez
2. Karl Beecher, Computational Thinking – A beginners guide to problem solving and programming, BCS, 1e, THE CHARTERED INSTITUTE FOR IT, 2017
3. Peter J. Denning, Matti Tedre, Computational Thinking, MIT Press, 2019
4. Peter William Mcowan, Paul Curzon, Power Of Computational Thinking, World Scientific, 2017

| Semester 2 | | | | | | |
|--|---|------|------|------|-------------------------|-------------------|
| 24-813-0201 | Fundamentals of Programming (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO 1 | Understand the fundamentals of programming and learn to write programs. | | | | | Understand |
| CO 2 | Analyze the different the programming structures such as decision making statements, loops, arrays and functions. | | | | | Analyze |
| CO 3 | Understand the basic concepts of OOP and learn how to create and initialize objects using constructors. | | | | | Apply |
| CO 4 | Understand and analyze the different types of inheritance.. | | | | | Analyze |
| CO 5 | Understand the usage of polymorphism, template classes, namespaces and exception handling | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |

| | | | | |
|-----|---|---|---|---|
| CO1 | 2 | 1 | - | - |
| CO2 | 2 | 1 | - | - |
| CO3 | 2 | 1 | - | - |
| CO4 | 1 | 1 | - | - |
| CO5 | 2 | 1 | - | - |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Introduction to Programming: Basic Difference between Procedure Oriented Language and Object Oriented Language, Concepts of Machine level, Assembly level and High level programming, Flow charts and Algorithms. Fundamentals of C: Features of C language, structure of C program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions.

Module 2(10 Lectures)

Simple statements, Decision making statements, Looping statements, Nesting of control structures, break and continue statement. Array & String: Concept of array, One and Two dimensional arrays, declaration and initialization of arrays, String, String storage, Built-in string functions. Functions: Concept of user defined functions, prototype, definition of function, parameters, parameter passing, calling a function.

Module 3 (8 Lectures)

Introduction to OOP: Basic properties, Classes and Objects, Member functions and variables, Abstract data types (ADT), Encapsulation. Constructors: Parameterized Constructors, Copy Constructors, Dynamic Constructors, Destructors.

Module 4(10 Lectures)

Inheritance and Access Control: Member access control in classes, Friend functions and classes, Public Private and Protected Inheritance, Single – Multiple – Multilevel – Hierarchical – Hybrid inheritance.

Module 5 (8 Lectures)

Polymorphism: Runtime and compile time polymorphism, overloading functions and operators, Defining Operator Overloading, Overloading Operators, Rules for Overloading Operators, selecting friend member function for operator overloading, Virtual methods, pure virtual methods – Abstract classes. Template classes: Creating and using templates, Namespaces, Exception Handling, Inline functions

References

1. Yashavant Kanetkar: Let Us C, 15e, BPB Publications, 2016.
2. Herbert Schildt: C: The Complete Reference, 4e, McGraw Hill Education, 2017.
3. Pradip Dey, Manas Ghosh: Computer Fundamentals and Programming in C, 2e, Oxford University Press, 2013.
4. Bjarne Stroustrup: C++ Programming Language, 4e, Addison-Wesley, 2013.
5. Bjarne Stroustrup: Programming: Principles and Practice Using C++, 2e, Addison-Wesley, 2014.
6. Stanley Lippman, Josée Lajoie, Barbara Moo: C++ Primer, 5e, Addison-Wesley, 2012.

| Semester 3 | | | | | | |
|--|--|------|------|------|-----------------------------|--------|
| 24-813-0301 | Data Structures (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand different asymptotic notations to analyze performance of algorithms. | | | | Understand | |
| CO2 | Use elementary and advanced data structures such as Array, Linked list, Tree and Graph to solve real world problems efficiently. | | | | Apply | |
| CO3 | Implement searching and sorting methods. | | | | Apply | |
| CO4 | Understand different memory management techniques and their significance. | | | | Analyze | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 3 | 1 | - | | |
| CO2 | 3 | 2 | 1 | - | | |
| CO3 | 3 | 2 | 1 | - | | |
| CO4 | 3 | 2 | - | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1 | | | | | | |

Introduction to programming methodologies – structured approach, stepwise refinement techniques, programming style, documentation. Elementary data organization - Data structure - Data structure operation - Analysis of algorithms: frequency count, definition of Big O notation, asymptotic analysis of simple algorithms - Recursive and iterative algorithms.

Module 2

Array, Records and Pointers: Introduction, Linear array, Representation of linear array in memory, Traversing linear array, Inserting and Deleting, Sorting methods, Searching methods. String - representation of strings, concatenation, substring searching and deletion.

Module 3

Linked List: Introduction, Linked list, Representation of Linked list in memory, Searching a linked list, Memory allocation, Garbage collection, Insertion and deletion in linked list, doubly linked list, Circular linked list, applications of linked list: polynomials, Memory management, memory allocation and deallocation, First-fit, best-fit and worst-fit allocation schemes.

Module 4

Stacks, Queues, Recursion - Introduction, Stacks, Queues, Operations on stacks and Queues, Implementation of Stacks and Queues using arrays and linked list, Arithmetic expression evaluation, Recursion, DEQUEUE (double ended queue), Multiple Stacks and Queues, Applications.

Module 5

Tree - Introduction, Terminology of Binary tree, Types of Binary tree, Traversing of binary tree, Header Nodes, Threads. Binary search tree – creation, insertion and deletion and search operations, applications. B-Trees, B+-Trees. Hash Tables – Hashing functions – Mid square, division, folding, digit analysis, collision resolution and Overflow handling techniques.

References

1. Samanta D.: Classic Data Structures, 2e, Prentice Hall India, 2009.
2. Richard F. Gilberg, Behrouz A. Forouzan: Data Structures: A Pseudocode Approach with C, 2e, Cengage Learning, 2005.
3. Aho A. V., J. E. Hopcroft, J. D. Ullman: Data Structures and Algorithms, Pearson Publication, 1983.
4. Tremblay J. P., P. G. Sorenson: Introduction to Data Structures with Applications, 2e, Tata McGraw Hill, 1995.
5. Peter Brass: Advanced Data Structures, Cambridge University Press, 2008.
6. Lipschutz S.: Theory and Problems of Data Structures, Schaum's Series, 1986.
7. Wirth N.: Algorithms + Data Structures = Programs, Prentice Hall, 2004.
8. Horwitz E., S. Sahni, S. Anderson: Fundamentals of Data Structures in C, University Press (India), 2008.

| Semester 4 | | | | | | |
|--|---|------|------|------|-----------------------------|--------|
| 24-813-0401 | Advanced Programming with Java (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Develop object-oriented programming in Java, including defining classes, invoking methods, using libraries. | | | | Apply | |
| CO2 | Demonstrate the design, implementation, testing and debugging graphical user interfaces in Java. | | | | Apply | |
| CO3 | Illustrate Java Swings for designing GUI applications. | | | | Apply | |
| CO4 | Apply Database Connectivity and Network Programming Skills. | | | | Apply | |
| CO5 | Analyze and Evaluate Java Concurrency Mechanisms and Design Patterns. | | | | Analyze | |
| CO6 | Create and Design Robust Web Applications. | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | - | - | | |
| CO2 | 3 | 2 | - | - | | |
| CO3 | 2 | 2 | - | - | | |
| CO4 | 3 | 2 | - | - | | |
| CO5 | 2 | 2 | - | - | | |

| | | | | |
|-----|---|---|---|--|
| CO6 | 3 | 2 | 3 | |
|-----|---|---|---|--|

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Module 1

Java Overview – Java Virtual Machine – Introduction to Java Programming – Operators and Expressions Control Flow statements – Defining classes and creating objects in Java – Constructors – Access Modifiers Programs using Java objects - Inheritance – Abstract classes – Access Modifiers - final class – final method

Module 2

Method overriding – Polymorphism - Packages in Java – String Handling - Exception Handling - Parameter Passing - Java.io.package classes – Input/Output Streams – Reading console input – Collection framework Accessing Collection via Iterator interface – Utility Classes in Java

Module 3

Threads in Java – Thread class and Runnable interface – Thread Synchronization - Introduction To Swing, MVC Architecture, Applications and Pluggable Look and Feel, Basic swing components : Text Fields, Buttons, Toggle Buttons, Checkboxes, and Radio Buttons. Reflection in Java - Reading Type Information - Methods

Module 4

Java database Connectivity – JDBC overview JDBC Driver types – Loading Driver class – Obtaining Connection to database – Statement – Prepared Statement –Executing queries. Network Programming With java.net Package, Client and Server Programs, Content And Protocol Handlers.

Module 5

Java Concurrency - Semaphores - Monitor patterns - Executors: Managing Thread Pools - Concurrency Utilities: Concurrent HashMap, Countdown Latch ; Design Patterns - Introduction to Design Patterns - Creational Design Patterns - Structural Design Patterns - Behavioral Design Patterns Web Programming Options in Java - Java Servlets - JavaServer Pages (JSP) - Spring Framework - Java Server Faces (JSF)

References

1. Java 6 Programming, Black Book, Dreamtech
2. The Complete Reference, 9e, McGraw-Hill, 2017, Herbert Schildt
3. Java Server Programming, Java EE6 (J2EE 1.6), Black Book, Dreamtech
4. Advanced Java Technology, By M.T. Savaliya, Dreamtech

| Semester 4 | | | | | | |
|--|---|------|------|------|-------------------------|--------|
| 24-813-0402 | Digital Logic and Computer Organization (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Demonstrate understanding significance of number systems, conversions, binary codes, and digital logic gates. | | | | Apply | |
| CO2 | Illustrate knowledge on design of various combinational logic circuits and data processing circuits. | | | | Apply | |
| CO3 | Demonstrate understanding and analysis of arithmetic algorithms. | | | | Analyze | |
| CO4 | Demonstrate understanding of the basic structure, organization of computers. | | | | Understand | |
| CO5 | Demonstrate understand of central processing, I/O and memory organization. | | | | Understand | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 1 | 1 | 1 | - | | |
| CO2 | - | 1 | 1 | - | | |
| CO3 | 3 | 1 | - | - | | |
| CO4 | 1 | 1 | - | - | | |
| CO5 | - | 1 | - | - | | |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1 (8 Lectures)

Number Systems and Codes: Binary Number system – Binary to decimal – decimal to binary – hexadecimal – ASCII code – Excess-3 Code – Gray code. Digital Logic: The Basic Gates – NOT, OR, AND - Universal Logic Gates – NOR, NAND.

Module 2 (10 Lectures)

Combinational Logic Circuits: Boolean Laws and Theorems. - Sum of Products method - Truth table to Karnaugh Map – Pairs, Quads, Octets – Don't Care Conditions- Product-of sums method -Product-of sums Simplifications. Data Processing Circuits: Multiplexers – Demultiplexers-1-of-16 Decoder – BDC- to decimal Decoders – Seven-segment Decoders – Encoders – Exclusive-OR Gates- Parity Generators and Checkers.

Module 3 (8 Lectures)

Arithmetic Circuits: Binary Addition- Binary Subtraction – 2'S Complement Representation - 2'S Complement Arithmetic – Arithmetic Building Blocks.

Module 4 (10 Lectures)

Basic Computer organization and Design: Instruction codes - stored program organization - Computer registers and common bus system - Computer instructions - Timing and control - Instruction cycle: Fetch and Decode - Register reference instructions. Micro programmed Control: Control memory organization - Address sequencing, micro instruction format and symbolic microinstructions - symbolic micro-program - binary micro program.

Module 5 (8 Lectures)

Central Processing Unit: General register organization - stack organization – instruction formats - addressing modes - Data transfer and manipulation - Program control. CISC and RISC - Parallel processing - Pipeline- general consideration. Input-output organization: Peripheral devices - I/O interface - Memory organization: Memory hierarchy - Main memory - Auxiliary memory.

References

1. Digital Principles and Applications – Donald P Leach, Albert Paul Malvino, GoutamSaha, 8th edition , McGraw-Hill Education, 3rd reprint 2015.
2. R. P. Jain, “Modern Digital Electronic”, McGraw-Hill Publication, 4thEdition.
3. William Stalling, “Computer Organization and Architecture: Designing and Performance”, Pearson Publication 10TH Edition.
4. Computer System Architecture, M. Morris Mano, Pearson Education, 3rd edition.,2007
5. Digital design, R.Anantha Natarajan, PHI Learning, 2015.

| Semester 4 | | | | | | |
|--|---|------|------|------|-------------------------|-------------------|
| 24-813-0403 | Introduction to Artificial Intelligence (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understanding of AI Concepts | | | | | Understand |
| CO2 | Demonstrate knowledge of various AI algorithms, techniques, and models | | | | | Apply |
| CO3 | Apply AI techniques to solve real-world problems and demonstrate critical thinking skills | | | | | Apply |
| CO4 | Understand knowledge-based systems. | | | | | Understand |
| CO5 | Know ethical concerns | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 3 | 3 | - | | |
| CO2 | 3 | 3 | 3 | - | | |
| CO3 | 3 | 3 | 3 | - | | |
| CO4 | 3 | 3 | 3 | - | | |
| CO5 | 3 | 2 | 3 | 3 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module -1(8 Lectures)

Introduction to AI, Evolution of AI, Turing test, Categories of AI, Applications of AI, Problem Definition as a State Space Search, Production System, Control Strategies

Module-2(10 Lectures)

Problem Solving - Solving problems by searching, Uninformed and Informed search strategies (Breadth First Search, Depth First Search, uniform cost search, iterative deepening, Hill climbing, Heuristics Search Techniques: Best First Search, A* algorithm, AO* algorithm, Min-max, Alpha – Beta pruning), Constraint satisfaction problems

Module-3 (8 Lectures)

Knowledge based agents, First order logic, Propositional logic, Agents based on propositional logic, Knowledge Representation - Ontological Engineering, Planning - Classical Planning, Heuristics for Planning and Hierarchical Planning.

Module-4(8 Lectures)

Philosophy, Ethics, and Safety of AI - Limits of AI, The Ethics of AI, AI Safety, Future of AI- AI Components, AI Architectures

Module-5 (6 Lectures)

AI Components, AI applications – Language Models – Information Retrieval- Information Extraction – Natural Language Processing.

References

1. Ethem Alpaydin, Machine Learning: The New AI, MIT Press, 2016
2. Stuart Russell and Peter Norvig, Artificial Intelligence - A Modern Approach, 3e, Pearson Education India, 2015
3. Andriy Burkov, The Hundred-Page Machine Learning Book, Andriy Burkov, 2019
4. Introduction to AI, Coursera
5. AI for everyone, Coursera
6. Jeff Heaton, Artificial Intelligence for Humans, CreateSpace, 2013
7. Mark Coeckelbergh, AI Ethics, MIT Press, 2020

| Semester 4 | | | | | | |
|--|---|------|------|------|-------------------------|-------------------|
| 24-813-0404 | Database Management Systems (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Apply Knowledge of Database Systems and Architectures. | | | | | Apply |
| CO2 | Design and Implement Relational Databases. | | | | | Apply |
| CO3 | Analyze and Normalize Database Designs. | | | | | Analyze |
| CO4 | Implement Transaction Management and Concurrency Control. | | | | | Apply |
| CO5 | Explore Advanced Database Concepts | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 1 | - | | |
| CO2 | 3 | 1 | 1 | - | | |
| CO3 | 3 | 1 | 1 | - | | |
| CO4 | 3 | 1 | 1 | - | | |
| CO5 | 3 | 2 | 1 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1

Introduction to Database Systems: Importance – Database architectures – Data model. Introduction to relational databases – Relational Model – Keys – Relational Algebra and Calculus. SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL

Module 2

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form- SQL Queries.

Module 3

Transaction management: Operations, Transaction Schedules, ACID properties. Concurrency control: Concurrency Control Problems,–Two-Phase Locking- Timestamp – Multiversion – Validation and Snapshot isolation– Multiple Granularity locking – Deadlock Handling, Recovery Concepts: Recovery based on deferred and immediate update – Shadow paging – ARIES Algorithm.

Module 4

Indexing – Cluster Indexes, Primary and Secondary Indexes – Index data Structures – Hash-Based Indexing – Tree base Indexing – Comparison of File Organizations – The Memory Hierarchy, RAID, Disk Space Management, Buffer Manager, Files of Records, Page Formats, Record Formats.

Module 5

Distributed Databases: Architecture, Data Storage, Transaction Processing, Query processing, and optimization – NoSQL Databases: Introduction – CAP Theorem – Document-Based systems – Key value Stores – Column-Based Systems – Graph Databases-Cloud Databases.

References

1. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, "Database System Concepts", Seventh Edition, McGraw Hill, 2020.
2. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Seventh Edition, Pearson Education, 2017
3. Raghu Ramakrishna, Johannes Gehrke, "Data base Management Systems", TATA McGraw Hill 3rd Edition
4. M. Tamer OZSU and Patuck Valduriez, " Principles of Distributed Database Systems", Pearson Edn. Asia, 2001.

| Semester 4 | | | | | | |
|--|---|--------|------|------|-------------------------|--------|
| 24-813-0405 | Python for Data Science and Machine Learning (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | CS SEC | 3 | 1 | 2 | 3 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Apply Python syntax and semantics to write well-structured and efficient programs | | | | Apply | |
| CO2 | Utilize functions with arguments to modularize code and improve reusability | | | | Understand | |
| CO3 | Apply core data structures to organize and manipulate data in Python programs. | | | | Apply | |
| CO4 | Apply techniques to read data from and write data to files using Python. | | | | Apply | |
| CO5 | Interact with the operating system using Python libraries to automate file management and system commands | | | | Understand | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 1 | - | | |
| CO2 | 3 | 1 | 1 | - | | |
| CO3 | 3 | 1 | 1 | - | | |
| CO4 | 3 | 1 | 1 | - | | |
| CO5 | 3 | 2 | 1 | - | | |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation

Syllabus

Module 1

Programming Environment and Python Basics: Getting Started with Python Programming - Running code in the interactive shell, Editing, Saving, and Running a script. Using editors - Jupyter. Working with data types, Numeric data types and Character sets, Keywords, Variables and Assignment statement, Operators, Expressions, Working with numeric data, Type conversions, Building Python Programs: Control statements - Selection structure (if-else, switch-case), Iteration structure(for, while), Testing the control statements

Module 2

Functions - Hiding redundancy and complexity, Arguments and return values, Variable scopes and parameter passing, Named arguments, Main function, Strings and number systems - String function, Data Representation: Lists - Basic list Operations and functions, List of lists, Slicing, Searching and sorting list, List comprehension.

Module 3

Work with tuples, Sets. Work with dates and times. Dictionaries - Dictionary functions, dictionary literals, adding and removing keys, accessing and replacing values, traversing dictionaries,

Module 4

Data Processing: The os and sys modules. Introduction to file I/O - Reading and writing text files, Manipulating binary files. NumPy - Basics, Creating arrays, Arithmetic, Slicing, Matrix Operations, Random numbers. Plotting and visualization.

Module 5

Matplotlib - Basic plot, Ticks, Labels, and Legends. Working with CSV files. – Pandas - Reading, Manipulating, and Processing Data

Textbook/ References

1. Kenneth A Lambert., Fundamentals of Python : First Programs, 2/e, Cengage Publishing, 2016
2. Wes McKinney, Python for Data Analysis, 2/e, Shroff / O’Reilly Publishers, 2017
3. Flask: Building Python web services, Jack Stouffer, Shalabh Aggarwal, Gareth Dwyer, PACKT Publishing Limited, 2018
4. Zed A Shaw, Learn Python 3 The Hard Way, Addison-Wesley, 2017
5. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2/e, Schroff, 2016
6. Michael Urban and Joel Murach, Python Programming, Shroff/Murach, 2016

| Semester 5 | | | | | | |
|---|---|------|------|------|-------------------------|--------|
| 24-813-0501 | Mathematics for Computing (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Analyze the different methods for proving the correctness of the theorems and problems. | | | | Analyze | |
| CO2 | Apply the basic concepts of Linear Algebra. | | | | Apply | |
| CO3 | Apply the basic aspects of graph theory. | | | | Apply | |
| CO4 | Apply the fundamentals of probability theory. | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | - | - | | |
| CO2 | 2 | 1 | - | - | | |
| CO3 | 2 | 1 | - | - | | |
| CO4 | 2 | 1 | - | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1 | | | | | | |
| Introduction – proofs – propositions – predicates and quantifiers – truth tables – first order logic – satisfiability – pattern of proof – proofs by cases – proof of an implication – proof by | | | | | | |

contradiction – proving iff – sets – proving set equations – Russell’s paradox – well-ordering principle – induction – invariants – strong induction – structural induction

Module 2

Vectors-Coordinate system-vector addition-vector multiplication-Linear combinations, span, and basis vectors-Matrix multiplication as composition-Three-dimensional linear transformations-The determinant-Inverse matrices, column space and null space- Nonsquare matrices as transformations between dimensions-Dot products and duality-Cross products-Cross products in the light of linear transformations-Cramer's rule-Change of basis-Eigenvectors and eigenvalues-vector spaces

Module 3

Graph theory – simple graphs – isomorphism – subgraphs – weighted graphs – matching problems – stable marriage problem – graph coloring – paths and walks – shortest paths – connectivity – Eulerian and Hamiltonian tours – travelling salesman problem – trees – spanning trees – planar graphs – Euler’s formula – directed graphs – strong connectivity – relations – binary relations – surjective and injective relations symmetry, transitivity, reflexivity, equivalence of relations – posets and dags – topological sort.

Module 4

Probability – events and probability spaces – conditional probability – tree diagrams for computing probability – sum and product rules of probability – A posteriori probabilities – identities of conditional probability – independence – mutual independence – birthday paradox – random variables – indicator random variables.

Module 5

Probability distribution functions – Bernoulli, Uniform, Binomial, Poisson, Normal distributions – Expectation – linearity of expectations – sums of indicator random variables – expectation of products – variance and standard deviation of random variables – Markov and Chebyshev’s theorems – Bounds for the sums of random variables.

References

1. Bronson, R., Costa, G.B., Saccoman, J.T. and Gross, D., Linear algebra: algorithms, applications, and techniques. 4e, 2023.
2. Eric Lehman, F Thomson Leighton, Albert R Meyer, Mathematics for Computer Science, 1e, MIT, 2010.
3. Susanna S. Epp, Discrete Mathematics with Applications, 4e, Brooks Cole, 2010.
4. Gary Chartrand, Ping Zhang, A First Course in Graph Theory, 1e, Dover Publications, 2012.
5. Michael Sipser, Introduction to Theory of Computation, 3e, Cengage, 2014.
6. Sheldon Ross, A First Course in Probability, 9e, Pearson, 2013.
7. Tom Leighton, and Marten Dijk. 6.042J Mathematics for Computer Science. Fall 2010. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>.

8. John Tsitsiklis. 6.041SC Probabilistic Systems Analysis and Applied Probability. Fall 2013.
9. Massachusetts Institute of Technology: MIT OpenCourseWare. <https://ocw.mit.edu>
10. Igor Pak. 18.315 Combinatorial Theory: Introduction to Graph Theory, Extremal and Enumerative Combinatorics. Spring 2005. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>
11. Albert Meyer. 6.844 Computability Theory of and with Scheme. Spring 2003. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>.
12. Shai Simonson , Theory of Computation, <http://www.aduni.org/courses/theory/>

| Semester 5 | | | | | | |
|---|--|------|------|------|-------------------------|--------|
| 24-813-0502 | Fundamentals of Data Science (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamental concepts and processes of data science ,encompassing data engineering , data analysis and model building. | | | | Understand | |
| CO2 | Gain practical experience in data wrangling ,exploratory data analysis and visualization | | | | Analyze | |
| CO3 | Develop essential skills for data mining, predictive analytics, and recommendation systems. | | | | Apply | |
| CO4 | Explore the integration of data science with software development and security practices (DevSecOps). | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 3 | - | | |
| CO2 | 3 | 2 | 3 | - | | |
| CO3 | 3 | 2 | 3 | - | | |
| CO4 | 3 | 2 | 3 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1 | | | | | | |
| Understanding the data science lifecycle: data acquisition, preprocessing, analysis, visualization, and communication. Ethical considerations in data collection, analysis, and | | | | | | |

responsible data science practices. Data pre-processing techniques, handling missing values, outliers, and inconsistencies. Data transformation, including feature engineering and scaling techniques.

Module 2

Data mining concepts and techniques for extracting hidden patterns and insights. Association Rule Learning; Decision Trees: mining graph data, Cluster Analysis, Finding similar items, mining data streams, frequent item sets, link analysis, predictive models, descriptive models, and decision models.

Module 3:

Introduction to popular Python libraries for data science Pandas, NumPy. Applied statistics in Python, Statistical modelling with scipy.

Module 4:

Data visualization and exploration: creating plots and charts to explore relationships between variables, identify patterns or outliers, and communicate insights. Descriptive statistics: computing measures such as mean, median, standard deviation, or correlation coefficients to understand the distribution of data. Clustering and dimensionality reduction: Data visualization principles: choosing appropriate chart types, effective communication through visuals. Feature engineering.

Module 5

Introduction to recommendation systems and their applications. Collaborative filtering and content-based filtering techniques for recommendation. Integrating data science models into web applications and APIs. Understanding DevSecOps principles for secure development, deployment, and monitoring of data-driven applications. Case study

References/Text Books

1. Python Data Science Handbook by Jake VanderPlas (O'Reilly Media, 2016)
2. Davy Cielen, Arno DB Meysman and Mohamed Ali. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016
3. **Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow** by Aurélien Géron (O'Reilly Media, 2019)
4. **Data Science in Production: Building Scalable Model Pipelines** by Jake VanderPlas (O'Reilly Media, 2020)

| Semester 5 | | | | | | |
|--|--|------|------|------|-----------------------------|-------------------|
| 24-813-0503 | Operating Systems (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Explain the objectives and functions of operating systems | | | | | Understand |
| CO2 | Analyze the tradeoffs inherent in operating system design | | | | | Analyze |
| CO3 | Apply the CPU Scheduling Algorithms | | | | | Apply |
| CO4 | Analyze process synchronization and deadlock mechanism in OS | | | | | Analyze |
| CO5 | Understand memory management mechanism and file system in OS | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 1 | 1 | - | - | | |
| CO2 | 1 | 1 | - | - | | |
| CO3 | 1 | 1 | - | - | | |
| CO4 | 1 | 1 | - | - | | |
| CO5 | 1 | 1 | - | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |

Module 1(8 Lectures)

Overview of Operating Systems- Characteristics of OS, Types of OS, OS Operations, Resource Management, Kernel Data Structure- Operating System Structure, OS Services, System Call, Linkers and Loaders .

Module 2(8 Lectures)

Processes-Process concept, forks and pipes, Interrupt processing, Process Scheduling, Inter Process Communication-Threads And Concurrency- CPU Scheduling Algorithms

Module 3 (8 Lectures)

Process Synchronization- Critical Section Problem, Peterson's Solution, Mutex Locks, Semaphores, Deadlocks-Methods of Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Recovery from Deadlock

Module 4(10 Lectures)

Memory Management and Virtual Memory - Logical versus Physical Address Space, Swapping, Contiguous Allocation, Paging, Segmentation, Segmentation with Paging, Demand Paging, Page Replacement, Page Replacement Algorithms, Thrashing

Module 5 (10 Lectures)

File System- File concept, Access methods, Directory Structure, Memory Mapped Files, Blocks and Fragments, Directory tree, Inodes, File descriptors, UNIX file structure, Secondary Storage Management - Disk components, Disk scheduling, Swap-space management, Protection and Security, Routing, Connection strategies, Remote File Systems.

References

1. Operating System Principles, Abraham Silberchatz, Peter B.Galvin,Greg Gagne,10th Edition, Wiley Student Edition. 2018
2. Operating System-Internals and Design Principles, W.Stallings, 6th Edition, Pearson. Strang,
3. Gilbert. Modern Operating System, Andrew s Tanenbaum, 3rd Edition, PHI
4. Operating System A concept-based Approach, 2nd Edition, D.M.Dhamdhere, TMH/
5. Principle Of Operating Systems, B.LStuart, Cengage Learning, India Edition
6. An Introduction to Operating System, P.C.P.bhatt, PHI.

| Semester 5 | | | | | | |
|--|--|------|------|------|-----------------------------|----------------|
| 24-813-0504 | Theory of Computation (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO 1 | Interpret the mathematical foundations of computation including automata theory. | | | | | Analyze |
| CO 2 | Interpret the theory of formal languages and grammars. | | | | | Analyze |
| CO 3 | Construct the abstract machines including finite automata, pushdown automata, and Turing machines from their associated languages and grammar. | | | | | Apply |
| CO 4 | Make use of pumping lemma to show that a language is not regular / not context-free. | | | | | Apply |
| CO 5 | Construct the grammar for any given finite automata, pushdown automata or Turing machines. | | | | | Apply |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 1 | 2 | 2 | - | | |
| CO3 | 1 | 3 | 2 | - | | |
| CO4 | 1 | 3 | 1 | - | | |
| CO5 | 1 | 3 | 1 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1(8 Lectures)

Introduction to Automata Theory. Languages, Grammars, Automata and their applications, Type 3 Formalism, Finite state automata – Properties, Designing finite automata.

Module 2(10 Lectures)

Myhill-Nerode Theorem, Minimal FA Computation. Finite State Machines with Output-Mealy and Moore machine (Design Only), Minimization of FA, NFA, Equivalence of NFA and DFA, Finite Automata with Epsilon Transitions.

Module 3 (8 Lectures)

Regular Languages-properties, Regular Expressions-Properties, Equivalence of DFA and Regular Expressions. Pumping Lemma for Regular Languages, Applications of Pumping Lemma. Closure Properties of Regular sets.

Module 4(10 Lectures)

Push down automata, languages accepted by push down automata - Connection with Context free languages - Properties of context free languages, pumping lemmas, Context-sensitive Grammar, and Linear Bounded Automata

Module 5 (8 Lectures)

Variants of TMs -Universal Turing Machine, Multi-tape TMs, non-deterministic TMs, Recursively Enumerable Languages, Recursive languages, Properties of Recursively Enumerable Languages and Recursive Languages, Decidability and Halting Problem. Chomsky Hierarchy.

References

1. Peter Linz, An Introduction to Formal Languages and Automata, Jones & Bartlett Learning, 6e, 2016.
2. John E Hopcroft, Rajeev Motwani and Jeffrey D Ullman, Introduction to Automata Theory, Languages, and Computation, 3e, Pearson Education, 2007
3. John C Martin, Introduction to Languages and the Theory of Computation, TMH, 2007
4. Michael Sipser, Introduction to Theory of Computation, Cengage Publishers, 2013.

| Semester 5 | | | | | | |
|--|---|------|------|------|-------------------------|-------------------|
| 24-813-0505 | Design and Analysis of Algorithm (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the basic concepts of design and analysis of fundamental algorithms. | | | | | Understand |
| CO2 | Develop the ability to design algorithms to attack new problems. | | | | | Apply |
| CO3 | Prove the correctness of algorithms. | | | | | Analyze |
| CO4 | Develop the ability to analyze the complexity of algorithms. | | | | | Apply |
| CO5 | Understand Complexity classes, concepts of P and NP problems. | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 1 | - | | |
| CO2 | 3 | 3 | 2 | - | | |
| CO3 | 3 | 2 | 2 | - | | |
| CO4 | 3 | 3 | 2 | - | | |
| CO5 | 3 | 2 | 1 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |

Module 1

Introduction to design and analysis of algorithms, models of computation, correctness proofs, insertion sort, computational complexity, Master theorem , proof of Master theorem, merge sort, Quick sort, heaps, heap sort, binary search, binary search trees.

Module 2

Graph algorithms, BFS and DFS, Dijkstra's algorithm, proof of correctness of Dijkstra's algorithm, Complexity analysis of Dijkstra's algorithm , Negative weight edges and cycles , Bellman-Ford algorithm, proof of correctness and complexity of Bellman-Ford, All pairs shortest paths, Floyd-Warshall algorithm, proof of correctness and complexity, Minimum Spanning Trees , Prim's algorithm, Cut property, Kruskal's algorithm, proof of correctness and complexity analysis of Kruskal's Algorithm, Maximum-Flow networks, Ford-Fulkerson method, proof of correctness and complexity, Edmonds-Karp algorithm.

Module 3

Probability review, Experiments, outcomes, events, Random variables, Expectation, Linearity of Expectation, Indicator Random Variables, Hiring Problem, Quicksort , Best case and Worst case complexity, Randomized Quicksort , Average case complexity , Hashing, Chaining, Open Addressing, Universal Hashing, Perfect Hashing , Analysis of hashing operations.

Module 4

Dynamic Programming, Rod-cutting problem, Recursive formulation, Bottom-up reformulation of recursive algorithms, Optimal Substructure Property, Matrix chain multiplication, Complexity of dynamic programming algorithms, Sequence Alignment , Longest common subsequence, Greedy algorithms, Optimal substructure and greedy-choice properties , 0-1 and fractional Knapsack problems, Huffman coding.

Module 5

P vs NP, NP Hardness, Reductions, Travelling Salesman Problem, NP-Completeness, SAT, 2-SAT and 3-SAT, Vertex Cover.

References

1. Thomas H. Cormen et al, Introduction to Algorithms, 3e, MIT Press, 2009.
2. Jon Kleinberg, Eva Tardos, Algorithm Design, 2e, Pearson, 2015.
3. Robert Sedgewick, Kevin Wayne, Algorithms, 4e, AW Professional, 2011
4. Steven S. Skiena, The Algorithm Design Manual, 2e, Springer, 2011

| Semester 5 | | | | | | |
|--|---|--------|------|------|-------------------------|-------------------|
| 24-813-0506 | R for Data Science (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | CS SEC | 3 | 1 | 2 | 3 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the use of R for data analytics. | | | | | Understand |
| CO2 | Learn to apply R programming for Text processing. | | | | | Apply |
| CO3 | Perform appropriate statistical tests using R. | | | | | Apply |
| CO4 | Create and edit visualizations with R. | | | | | Apply |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 3 | - | | |
| CO3 | 3 | 3 | 3 | - | | |
| CO4 | 3 | 3 | 3 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1 | | | | | | |
| R Programming Basics: Overview of R programming, Environment setup with R Studio, R Commands, Variables and Data Types, Control Structures, Array, Matrix. | | | | | | |

Module 2

Vectors, Factors, Functions, R packages, Reading and getting data into R (External Data): Using CSV files, XML files, Web Data, JSON files, Databases, Excel files.

Module 3

Data Visualization using R: Working with R Charts and Graphs: Histograms, Boxplots, Bar Charts, Line Graphs, Scatterplots, Pie Charts.

Module 4

Statistics with R: Random Forest, Decision Tree, Normal and Binomial distributions , Linear and Multiple Regression, Logistic Regression, Time Series Analysis.

Module 5

String Manipulation – Graphics –Creating Graphs – Customizing Graphs – Saving graphs to files – Creating three-dimensional plots

References

1. W. N. Venables, D.M. Smith and the R Development Core Team, An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics.
URL: <https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf>
2. Norman Matloff, The Art of R Programming – A Tour of Statistical Software Design, 1e, No Starch Press, 2011.
3. Jared P. Lander, R for Everyone: Advanced Analytics and Graphics, 1e, Pearson Education India, 2014.
4. Mark Gardener, Beginning R - The Statistical Programming Language, John Wiley & Sons, Inc., 2013.

| Semester 6 | | | | | | |
|--|--|------|------|------|-------------------------|--------|
| 24-813-0601 | Machine Learning (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand and explain the different types of the learning process, and key ethical considerations. | | | | Understand | |
| CO2 | Learn to effectively prepare data for machine learning models through data cleaning, feature selection, and dimensionality reduction. | | | | Apply | |
| CO3 | Implement and interpret linear and non-linear regression models, while comparing various classification techniques including tree-based, kernel, and ensemble methods. | | | | Apply | |
| CO4 | Gain practical knowledge in identifying data clusters using various algorithms and discovering hidden patterns through association rule learning. | | | | Apply | |
| CO5 | Understand the basic building blocks of neural networks, implement the backpropagation algorithm, and explore the concept of MDPs and Q-learning | | | | Understand | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 3 | 3 | | |
| CO2 | 3 | 3 | 3 | - | | |
| CO3 | 3 | 3 | 3 | - | | |
| CO4 | 3 | 3 | 3 | - | | |
| CO5 | 3 | 3 | 3 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1

Introduction to AI - What is AI? A Brief History of AI - Different types of AI - Applications of AI - Problem Solving Methods – Heuristics. Knowledge Representation and Reasoning - Planning and Decision-Making: Ethics and Societal Impact of AI.

Module 2

Machine Learning Fundamentals - Concept of Machine Learning: Definition, Applications, Types of learning (supervised, unsupervised, reinforcement) - Hypothesis Spaces and Inductive Bias - Learning Process- Machine Learning Ethics and Bias. Data Preprocessing and Feature Engineering: Data Representation - Data Preprocessing - Features and Types - Dimensionality Reduction – Feature Identification - Feature selection – Feature extraction - Feature Importance.

Module 3

Regression and Classification - Regression: Linear Regression – Non-Linear regression – evaluation metrics for regression– Classification: Binary, multi-class, and multi-label classification – lazy learners - tree-based techniques - kernel-based techniques - probabilistic techniques - and ensembled techniques – evaluation metrics for classification.

Module 4

Clustering and Rule Mining - Clustering: Partitioning based – hierarchical based – density based– grid-based – model based - Rule mining: Apriori algorithm, FB Growth - association rules. Outlier Detection - LOF.

Module 5

Artificial Neural Networks and Reinforcement Learning -Neural Networks: McCulloch-Pitts neurons, Hebb's networks, Hopfield networks, Boltzmann machines, Perceptrons, multilayer perceptrons, backpropagation. Reinforcement Learning: Markov Decision Processes (MDPs), Q-learning.

References

1. Ethem Alpaydin, Introduction to Machine Learning, 3e, MIT Press, 2014.
2. Tom M. Mitchell, Machine Learning, McGraw Hill Education; 1e, 2017.
3. Stephen Marsland, Machine Learning, An Algorithmic Perspective, 2e, CRC Press, 2015.
4. Giuseppe Bonaccorso, Machine Learning Algorithms, 1e, Packt Publishing Limited, 2017.
5. Ethem Alpaydin, Machine Learning- The New AI, MIT Press, 1e, 2016.
6. Andrew Ng, Machine Learning Yearning, ATG AI (Draft version), 1e, 2018.
7. Rohit Singh, Tomi Jaakkola, and Ali Mohammad. 6.867 Machine Learning. Fall 2006. Massachusetts Institute of Technology: MIT OpenCourseWare, <https://ocw.mit.edu>
8. Andrew Ng, <https://www.coursera.org/learn/machine-learning>

| Semester 6 | | | | | | |
|--|---|------|------|------|-------------------------|----------------|
| 24-813-0602 | Agile Software Engineering (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Create a software product architecture using UML | | | | | Apply |
| CO2 | Communicate with the development team using industry standard notations, designs and documentations. | | | | | Apply |
| CO3 | Estimate the cost of a software project and apply various techniques, metrics and strategies for testing software projects. | | | | | Analyze |
| CO4 | Work as a team leader by establishing goals and forming teams. | | | | | Apply |
| CO5 | Understand the user requirements and plan the development work using agile project management principles. | | | | | Analyze |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 3 | 3 | 1 | | |
| CO2 | 3 | 2 | 2 | - | | |
| CO3 | 3 | 3 | 2 | - | | |
| CO4 | 3 | 1 | 2 | 1 | | |
| CO5 | 3 | 2 | 2 | 1 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |

Module 1(8 Lectures)

Emergence of Software Engineering, Software design notations, Object-Oriented Analysis and Design using Unified Modelling Language (UML), Use Case Model Development, Object and Class Diagrams, Interaction Diagrams, Sequence models, Activity Diagrams, State Chart Diagrams, Package diagrams

Module 2

Software Life Cycle Models, Waterfall Model, Prototyping Model, Spiral Model, Software Requirements Specification, SRS Document, Function-oriented Design, , Scheduling, Critical Path Method, PERT Charts, Gantt Charts, Organization and Team Structures

Module 3

Metrics for Project Size Estimation, COCOMO Model, Software Quality, Software Quality Management System, Testing Concepts and Terminologies, Black-box Testing, White-Box Testing, Statement Coverage, Branch Coverage, Path Coverage, McCabe's Cyclomatic Complexity Metric, Software Maintenance.

Module 4

Agile Principles, Variability and Uncertainty, Work in Process, Progress, Performance, Scrum Framework, Scrum Roles, Responsibilities & Characteristics of Product Owner, ScrumMaster, Development Team, Sprints, Timeboxing, Sprint Planning, Sprint Execution

Module 5

Product Backlog, Good Product Backlog Characteristics, Requirements and User Stories, Characteristics of Good Stories, Estimation and Velocity, PBI Estimation Units, Planning Poker, Scrum Planning Principles, Product Planning (Envisioning), Portfolio Planning, Release Planning, Sprint Planning

References

1. Yashavant Kanetkar: Let Us C, 15e,BPB Publications, 2016.
2. Herbert Schildt: C: The Complete Reference, 4e, McGraw Hill Education, 2017.
3. Pradip Dey, Manas Ghosh: Computer Fundamentals and Programming in C, 2e, Oxford University Press, 2013.
4. Bjarne Stroustrup: C++ Programming Language, 4e, Addison-Wesley, 2013.
5. Bjarne Stroustrup: Programming: Principles and Practice Using C++, 2e, Addison-Wesley, 2014.
6. Stanley Lippman, Josée Lajoie, Barbara Moo: C++ Primer, 5e, Addison-Wesley, 2012.
7. Paul Deitel, Harvey Deitel: C++ How to Program, 10e, Pearson, 2016.
8. Timothy Budd: Introduction To Object-Oriented Programming, Pearson Education, 2008.
9. Walter J. Savitch, Kenrick Mock: Problem Solving with C++, 9e, Pearson Education, 2017.
10. Ira Pohl: Object-Oriented Programming Using C++, 2e, Addison-Wesley,1996.

| Semester 6 | | | | | | |
|--|--|------|------|------|---------------------|--------|
| 24-813-0603 | Computer Networks (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamental concepts of computer networking | | | | Understand | |
| CO2 | Apply various techniques for channel allocation, framing, error and flow control | | | | Apply | |
| CO3 | Analyze different networks and choose addresses for networking requirements | | | | Analyze | |
| CO4 | Acquire knowledge on various routing algorithms and design issues. | | | | Analyze | |
| CO5 | Develop an understanding of different transport layer and application layer protocols. | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 1 | - | 2 | - | | |
| CO2 | 1 | 2 | 2 | - | | |
| CO3 | 1 | 2 | 2 | - | | |
| CO4 | 1 | 1 | 2 | - | | |
| CO5 | 1 | 1 | 2 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus First module (8 Lectures) | | | | | | |

Introduction – Uses of computer networks, Network hardware, Network software, Reference models – The OSI reference model, The TCP/IP reference model.

Physical Layer – Modes of communication, Physical topologies, Signal encoding, Network devices, Transmission media. Performance indicators – Bandwidth, Throughput, Latency Queuing time, Bandwidth–Delay product.

Second module (8 Lectures)

Elementary Data Link Protocols, Error detection and correction, Sliding Window Protocols. Medium Access Control Layer - Channel Allocation Problem - Multiple Access Protocols.

Third module (8 Lectures)

Network layer Services, Datagram and Virtual circuit services, IP datagram format and Types of Services, The Original Classful Addressing Scheme Dotted Decimal Notation - Subnet and Classless Extensions - IP Multicast Addresses. ARP Protocol. Datagram encapsulation and Fragmentation, Reassembly and fragmentation, Routing Algorithms-Distance vector routing, Hierarchical routing, Link state routing, Broadcast routing.

Fourth module (8 Lectures)

Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). Transmission Control Protocol (TCP) – Overview of TCP, TCP segment header, Connection establishment & release, Connection management modelling, TCP retransmission policy, TCP congestion control

Fifth module (8 Lectures)

Application layer Protocols: - WWW and HTTP, FTP, DNS, SMTP, P2P File sharing, Domain Name System (DNS).

References

1. AS Tanenbaum, DJ Wetherall, Computer Networks, 5th Ed., Prentice-Hall, 2010.
2. LL Peterson, BS Davie, Computer Networks: A Systems Approach, 5th Ed., Morgan-Kaufman, 2011.
3. JF Kurose, KW Ross, Computer Networking: A Top-Down Approach, 5th Ed., Addison-Wesley, 2009.
4. W Stallings, Cryptography and Network Security, Principles and Practice, 5th Ed., Prentice-Hall, 2010

| Semester 6 | | | | | | |
|--|---|------|------|------|-----------------------------|--------|
| 24-813-0604 | Natural Language Processing (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Define the phases of traditional NLP as well as various NLP tasks | | | | Apply | |
| CO2 | Apply Hidden Markov Models, and Naive Bayes models for various NLP tasks. | | | | Apply | |
| CO3 | Apply word embedding techniques and N-gram language models for Named Entity Recognition | | | | Apply | |
| CO4 | Apply deep learning models like LSTM, GRU for sequence modeling, and CNN for coreference resolution | | | | Apply | |
| CO5 | Apply Seq2Seq models with attention mechanisms for natural language generation | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 3 | - | | |
| CO3 | 3 | 3 | 3 | - | | |
| CO4 | 3 | 3 | 3 | - | | |
| CO5 | 3 | 3 | 3 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1

Introduction to NLP, Phases of Traditional NLP - Lexical Analysis, Syntactic Analysis, Semantic Analysis, Discourse Analysis, Pragmatic Analysis. Introduction to NLP Tasks - Parts-of-Speech Tagging, Word Sense Disambiguation, Anaphora Resolution, Text classification, Recognizing Textual Entailment, Named Entity Recognition

Module 2

Introduction to Statistical NLP. Vector Space Models - Bag-of-Words, TF-IDF weighing, PPMI. Basics of Supervised and Semi-supervised Learning for various NLP tasks - Noisy Channel Model for spelling correction. Hidden Markov Models for POS Tagging, Naive Bayes model for Text Classification.

Module 3

Introduction to Neural NLP - Word Embedding - Contextual and non-contextual Word Embedding. Subword embeddings. Evaluation of word vectors. N-gram language models. Neural Networks for named entity recognition - Word window classification.

Module 4

Recurrent neural networks for language modeling and other tasks, GRUs and LSTMs for machine translation, Question answering and dialogue system, Recursive neural networks for parsing, Convolutional neural networks for Coreference resolution.

Module 5

Natural Language Generation - Seq2Seq models - Attention - Case studies and real-world applications of NLP in various domains. Introduction to Large Language Models.

References

1. Dan Jurafsky and James H. Martin. Speech and Language Processing (2024 pre-release)
2. Jacob Eisenstein. Natural Language Processing
3. Yoav Goldberg. A Primer on Neural Network Models for Natural Language Processing
4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning
5. Delip Rao and Brian McMahan. Natural Language Processing with PyTorch.
6. Lewis Tunstall, Leandro von Werra, and Thomas Wolf. Natural Language Processing with Transformers

| Semester 6 | | | | | | |
|---|---|------|------|------|-------------------------|--------|
| 24-813-0605 | Mini Project – 1 (Course Level 300-399) | TYPE | L | T | P | CREDIT |
| | | DSC | 0 | 0 | 4 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Create innovative solutions to real world problems by applying advanced programming techniques with requirement analysis and identification of design methodologies | | | | Apply | |
| CO2 | Function effectively as an individual and as a leader in diverse teams to plan and execute project utilizing available resources within timelines, following ethical and professional norms | | | | Apply | |
| CO3 | Organize and communicate technical and scientific findings effectively in written and oral forms | | | | Analyze | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 3 | 3 | 1 | | |
| CO2 | 3 | 2 | 3 | 3 | | |
| CO3 | 2 | 3 | 3 | 2 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| <p>The objective of this course is to apply the fundamental concepts of Software Engineering principles for the effective development of an application/research project. This course helps the learners to practice the different steps to be followed in the software development process such as literature review and problem identification, preparation of Software Requirement Specification & Software Design Document (SDD), testing, development and deployment.</p> <p>Guides are allotted at the beginning of the semester. A team consists of only one student. Student should identify a topic of interest in consultation with the Guide, review the literature and gather information pertaining to the chosen topic.</p> | | | | | | |

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. The students should record in the daily/weekly activity diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the review, design and all the observations made by the student and guide. The diary shall be signed every week by the guide.

The progress of the mini project is evaluated based on a minimum of two reviews by the committee. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester.

Preparing a paper for Conference/Publication in Journals is desirable for the successful completion of course. Students are also encouraged to present projects in Project Expos conducted at state level as well as others conducted in India and abroad

| Semester 6 | | | | | | |
|--|---|--------|------|------|---------------------|--------|
| 24-813-0606 | Web Technologies (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | CS SEC | 3 | 1 | 2 | 3 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Develop interactive Web pages using HTML/XHTML. | | | | | Apply |
| CO2 | Present a professional document using Cascaded Style Sheets | | | | | Apply |
| CO3 | Construct websites for user interactions using JavaScript and JQuery | | | | | Apply |
| CO4 | Know the different information interchange formats like XML and JSON. | | | | | Apply |
| CO5 | Develop Web applications using PHP. | | | | | Apply |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 2 | 3 | 1 | - | | |
| CO2 | 2 | 3 | 1 | - | | |
| CO3 | 2 | 3 | 1 | - | | |
| CO4 | 2 | 3 | 1 | - | | |
| CO5 | 2 | 3 | 1 | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |

Module 1 (7 Lectures)

Introduction to HTML/XHTML : Origins and Evolution of HTML and XHTML, Basic Syntax of HTML, Standard HTML Document Structure, Basic Text Markup, Images, Hypertext Links, Lists, Tables, Forms, HTML5, Syntactic Differences between HTML and XHTML.

Module 2(6 Lectures)

Introduction to Styles sheets and Frameworks: Cascading Style Sheets: Levels of Style Sheets - Style Specification Formats, Selector Forms, Property-Value Forms, Font Properties, List Properties, Alignment of Text, Color, The Box Model, Background Images, The span and div Tags.

Module 3 (7 Lectures)

The Basics of JavaScript: Overview of JavaScript, Object Orientation and JavaScript, General Syntactic Characteristics-Primitives, Operations, and Expressions, Screen Output and Keyboard Input, Control Statements, Object Creation and Modification, Arrays, Functions. Callback Functions, Java Script HTML DOM. Introduction to jQuery: Overview and Basics.

Module 4(6 Lectures)

XML: The Syntax of XML, XML Document Structure, Namespaces, XML Schemas, Displaying Raw XML Documents, Displaying XML Documents with CSS, XSLT Style Sheets, XML Applications. JSON(Basics Only): Overview, Syntax, Datatypes, Objects, Schema, Comparison with XML.

Module 5 (5 Lectures)

Introduction to PHP: Origins and Uses of PHP, Overview of PHP - General Syntactic Characteristics - Primitives, Operations, and Expressions - Control Statements, Arrays, Functions, Pattern Matching, Form Handling, Cookies, Session Tracking.

References

1. P. J. Deitel, H.M. Deitel, Internet &World Wide Web How To Program, 4/e, Pearson International Edition 2010.
2. Robert W Sebesta, Programming the World Wide Web, 7/e, Pearson Education Inc., 2014.
3. Bear Bibeault and Yehuda Katz, jQuery in Action, Second Edition, Manning Publications.[Chapter 1] Black Book, Kogent Learning Solutions Inc. 2009.
4. Bob Boiko, Content Management Bible, 2nd Edition, Wiley Publishers. [Chapter 1, 2]
5. Chris Bates, Web Programming Building Internet Applications, 3/e, Wiley India Edition 2009.
6. Dream Tech, Web Technologies: HTML, JS, PHP, Java, JSP, ASP.NET, XML, AJAX,

| Semester 7 | | | | | | |
|--|---|-------------|-------------|-------------|-------------------------|--------|
| 24-813-0701 | Deep Learning (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Apply basic supervised learning algorithms and optimization techniques for classification task. | | | | Apply | |
| CO2 | Apply techniques for regularizing deep networks and also be proficient in model exploration and hyperparameter tuning. | | | | Apply | |
| CO3 | Demonstrate the working of Convolution Operation, Sparse interactions, Parameter sharing, Equivariant representations, and Pooling. | | | | Apply | |
| CO4 | Apply deep recurrent networks such as Long Short-Term Memory (LSTM) and other Gated RNNs for sequence modeling tasks. | | | | Apply | |
| CO5 | Understand different types of Autoencoders including undercomplete, regularized, sparse, and denoising autoencoders. | | | | Understand | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | 2 | 2 | | |
| CO2 | 3 | 2 | 3 | 2 | | |
| CO3 | 3 | 3 | 3 | 3 | | |
| CO4 | 3 | 2 | 2 | 2 | | |
| CO5 | 3 | 1 | 1 | 1 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1

Introduction: Historical context and motivation for deep learning; basic supervised classification task, optimizing logistic classifier using gradient descent, stochastic gradient descent, momentum, and adaptive sub-gradient method.

Module 2

Neural Networks: Feedforward neural networks, deep networks, regularizing a deep network, model exploration, and hyperparameter tuning.

Module 3

Convolution Neural Networks: Introduction to convolution neural networks: stacking, striding and pooling, applications like image, and text classification.

Module 4

Sequence Modeling: Recurrent Nets: Unfolding computational graphs, recurrent neural networks (RNNs), bidirectional RNNs, encoder-decoder sequence to sequence architectures, deep recurrent networks - Long Short-Term Memory and Other GatedRNNs.

Module 5

Autoencoders: Undercomplete autoencoders, regularized autoencoders, sparse autoencoders, denoising autoencoders, representational power, layer, size, and depth of autoencoders, stochastic encoders, and decoders.

References

1. Ian Goodfellow, Deep Learning, MIT Press, 2016.
2. Jeff Heaton, Deep Learning and Neural Networks, Heaton Research Inc, 2015.
3. Mindy L Hall, Deep Learning, VDM Verlag, 2011

| Semester 7 | | | | | | | |
|--|--|------|------|------|---|------------------|--------|
| 24-813-0702 | BigData Analytics (Course Level 400-499) | | TYPE | L | T | P | CREDIT |
| | | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | | |
| CO1 | Understand the fundamental concepts of BigData | | | | | Understand | |
| CO2 | Understand about Hadoop and its ecosystem | | | | | Understand | |
| CO3 | Apply Bigdata analysis using PIG, HIVE and Spark | | | | | Apply | |
| CO – PSO Mapping | | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | | |
| CO1 | 3 | 1 | 2 | 2 | | | |
| CO2 | 3 | 1 | 2 | 2 | | | |
| CO3 | 3 | 2 | 3 | 2 | | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | | |
| Syllabus | | | | | | | |
| Module 1 (8 Lectures) | | | | | | | |
| Types of Digital Data, Big Data Characteristics, Types of Big Data, Infrastructure for Big Data, Big Data Challenges, Big Data Analytics, Application of Big data analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, | | | | | | | |
| Module 2 (8 Lectures) | | | | | | | |
| Hadoop Echo System, Hadoop file system interfaces, Data flow Map Reduce algorithm, Failures, Job Scheduling, Shuffle and Sort. | | | | | | | |

Module 3 (8 Lectures)

Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators.

Module 4 (8 Lectures)

Hive Architecture Comparison with Traditional Database, HiveQL Querying Data, Sorting And Aggregating, Map Reduce Scripts, Joins & Sub queries, HBase concepts, Advanced Usage, Schema Design, Advance Indexing

Module 5 (8 Lectures)

Spark programming. (Python and PySpark), Spark - Resilient Distributed Dataset (RDDs). Spark, RDDs, DataFrames, Spark SQL, PySpark + NumPy + SciPy, Code Optimization, Cluster Configurations

References

1. Big Data: A Revolution That Will Transform How We Live, Work, and Think by Viktor Mayer-Schonberger and Kenneth Cukier (Houghton Mifflin Harcourt, 2013)
2. **Pig: The Definitive Guide** by Julian Alvin Shaun Oak and Eric Sammer (O'Reilly Media, 2014)
3. **Learning Apache Hive** by Edward Capriolo, Noah Mischianti, and Joshua Wilson (O'Reilly Media, 2015):
4. **Hive Query Language: The Essential Guide** by Teja Deshpande and Ashish Thusoo (O'Reilly Media, 2011):
5. **High Performance Spark** by Holden Karau, Rachel Warren, and Matei Zaharia (O'Reilly Media, 2016)
6. **Learning Spark: Lightning-Fast Big Data Analytics** by Holden Karau, Rachel Warren, and Patrick Wendell (O'Reilly Media, 2015):
7. <https://spark.apache.org/docs/latest/quick-start.html>

| Semester 7 | | | | | | |
|---|--|-------------|-------------|-------------|-------------------------|-------------------|
| 24-813-0703 | Cloud computing and Virtualization (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand various basic concepts related to cloud computing technologies. | | | | | Understand |
| CO2 | Analyse benefits of virtualization for computing | | | | | Analyse |
| CO3 | Explore cloud technologies, architectures, and standards | | | | | Analyse |
| CO4 | Understand security vulnerabilities of cloud and apply solutions | | | | | Understand |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | 1 | 1 | | |
| CO2 | 3 | 2 | 2 | 1 | | |
| CO3 | 3 | 3 | 3 | 3 | | |
| CO4 | 3 | 2 | 2 | 3 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1 (8 Lectures) | | | | | | |
| Evolution of Computing: On-premise computing, client-server model, Distributed computing, multi-core computing. Virtualization: virtual machines, Desktop virtualization, hypervisor, microkernel, full and para virtualization. Benefits of cloud computing, Edge and fog computing, MQTT. | | | | | | |

Module 2(10 Lectures)

Cloud architecture: Layers in cloud architecture, Hosting and management of applications. Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS). Scalability and reliability in cloud. Examples for each model. SLAs. Hybrid cloud. Hyperconverged infrastructure.

Module 3 (8 Lectures)

Usage of cloud: AWS/ Azure/ GCP. Use of lambda or cloud functions as API. Storage of data in cloud. SCSI, SAN, NAS, etc. Software defined storage. Disaster recovery. Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph). Batch cloud computing: map-reduce and Hadoop.

Module 4(10 Lectures)

Web and Mobile applications communicating with cloud. Microservices vs Monolithic architectures. Applications of cloud computing healthcare, smart homes, smart grid, etc. Continuous Integration and Continuous deployment in Cloud: Automated build management, deployment and monitoring of applications. Clusters, Kubernetes, Use of Containers and docker.

Module 5 (8 Lectures)

Cloud security: Authentication and Authorization, Tokens, API Key, Identity and Access Management in cloud. Threat analysis for IoT: Types of Cyber Attacks on cloud and IoT and techniques to prevent such attacks. Securing IoT and Cloud: Encryption of data, symmetric and asymmetric key encryption. Digital Signatures and certificates.

References

1. Toby Velte, Anthony Velte, Robert Elsenpeter: Cloud Computing, A Practical Approach, 1e, McGraw-Hill Education, 2009.
2. Rajkumar Buyya, James Broberg, Andrzej Goscinski: Cloud Computing: Principles and Paradigms, 1e, Wiley, 2013.
3. Giacomo Veneri and Antonio Capasso, Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0, 1st Edition, Packt Publishing, 2018.
4. Mayur Ramgir, Internet of Things: Architecture, Implementation and Security, 1st Edition, Pearson, 2019.
5. R. Buyya, S N. Srirama, Fog and Edge Computing: Principles and Paradigms, Wiley Series on Parallel and Distributed Computing, 1st Edition, Wiley, 2019.

6. Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, 2nd Edition, MIT Press, 2017.

| Semester 7 | | | | | | |
|--|--|------|---|---|-------------------------|-------------------|
| 24-813-0704 | Cyber Security (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand foundational concepts in cybersecurity, including principles of confidentiality, integrity, and availability, and their application in securing information systems. | | | | | Understand |
| CO2 | Identify common cyber threats, vulnerabilities, and attack vectors, and apply appropriate security measures to mitigate risks. | | | | | Analyze |
| CO3 | Demonstrate proficiency in network security principles, including secure network design, implementation of access controls, and detection and prevention of network-based attacks. | | | | | Apply |
| CO4 | Analyze and assess security risks in operating systems, applications, and network infrastructures, and develop strategies to address identified vulnerabilities. | | | | | Analyze |
| CO5 | Apply cryptographic techniques to ensure the confidentiality, integrity, and authenticity of data in transit and at rest. | | | | | Apply |
| CO6 | Develop incident response plans and procedures to effectively detect, respond to, and recover from cybersecurity incidents. | | | | | Create |
| CO7 | Apply ethical hacking methodologies to identify and exploit security weaknesses in information systems, and recommend appropriate countermeasures. | | | | | Apply |
| CO8 | Understand legal and ethical considerations in cybersecurity, including compliance with relevant laws, regulations, and ethical standards. | | | | | Understand |
| CO – PSO Mapping | | | | | | |

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|------|------|
| CO1 | 3 | - | 1 | 1 |
| CO2 | 3 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 2 | 2 | 1 |
| CO5 | 3 | 2 | 2 | 1 |
| CO6 | 3 | 2 | 2 | 2 |
| CO7 | 3 | 3 | 3 | 3 |
| CO8 | 3 | 2 | 2 | 1 |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Overview of Cybersecurity: Introduction to cybersecurity concepts, importance, and challenges. Security Principles: Understanding security principles, CIA triad (Confidentiality, Integrity, Availability), and security models. Threat Landscape: Exploring common cyber threats, including malware, phishing, DDoS attacks, and social engineering. Risk Management: Introduction to risk assessment, risk mitigation strategies, and risk management frameworks.

Module 2(10 Lectures)

Network Fundamentals: Basics of networking, OSI model, TCP/IP protocol suite, and network devices. Network Attacks and Defense: Common network attacks (e.g., Man-in-the-Middle, DoS attacks), and network defense mechanisms (e.g., firewalls, IDS/IPS). Secure Network Design: Principles of secure network design, subnetting, VLANs, and DMZ configuration. Cryptography in Network Security: Introduction to cryptographic techniques used in securing network communication (e.g., encryption, digital signatures, key exchange).

Module 3 (8 Lectures)

Operating System Fundamentals: Overview of operating systems, user authentication, access control mechanisms, and file systems. OS Hardening: Techniques for hardening operating systems to improve security, including patch management, disabling unnecessary services, and using secure configurations. Endpoint Security: Endpoint protection mechanisms, antivirus

software, intrusion detection system(IDS), and host-based firewalls. Secure Administration: Best practices for secure system administration, including privilege management, logging, and auditing.

Module 4(10 Lectures)

Secure Software Development Lifecycle (SDLC): Introduction to secure SDLC phases, including requirements analysis, design, implementation, testing, and maintenance. Web Application Security: Common web vulnerabilities (e.g., SQL injection, XSS, CSRF) and techniques for securing web applications (e.g., input validation, parameterized queries). Secure Coding Practices: Best practices for writing secure code, secure coding guidelines, and code review techniques. Application Security Testing: Overview of security testing techniques, including static analysis, dynamic analysis, and penetration testing.

Module 5 (8 Lectures)

Incident Response Planning: Developing an incident response plan, incident detection and classification, and incident response phases. Digital Forensics: Introduction to digital forensics principles, evidence collection, preservation, and analysis. Ethical Hacking: Overview of ethical hacking methodologies, penetration testing techniques, and tools. Legal and Ethical Considerations: Understanding legal and ethical issues in cybersecurity, including laws, regulations, and professional codes of conduct.

References

1. William Stallings and Lawrie Brown - "Computer Security: Principles and Practice" (Pearson, 4th Edition, 2017)
2. William Stallings - "Network Security Essentials: Applications and Standards" (Pearson, 7th Edition, 2017)
3. Mike Chapple, James Michael Stewart, and Darril Gibson - "CISSP (ISC)2 Certified Information Systems Security Professional Official Study Guide" (Sybex, 8th Edition, 2018)
4. Dafydd Stuttard and Marcus Pinto - "The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws" (Wiley, 2nd Edition, 2011)
5. Jon Erickson - "Hacking: The Art of Exploitation" (No Starch Press, 2nd Edition, 2008)
6. Michael Sikorski and Andrew Honig - "Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software" (No Starch Press, 1st Edition, 2012)
7. Ross J. Anderson - "Security Engineering: A Guide to Building Dependable Distributed Systems" (Wiley, 2nd Edition, 2008)

| Semester 7 | | | | | | |
|--|--|------|------|------|---|-------------------------|
| 24-813-0705 | Image Processing and Computer Vision (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | | | | | Revised BT Level |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamental concepts of signal and image processing systems. | | | | | Understand |
| CO2 | Evaluate the different spatial and frequency domain filters for image enhancement and restoration. | | | | | Apply |
| CO3 | Evaluate the performance of periodic noise reduction filters and image segmentation algorithms. | | | | | Evaluate |
| CO4 | Understand the fundamental theories and techniques of computer vision and summarize different color and texture based feature extraction methods used for computer vision. | | | | | Understand |
| CO5 | Analyse different methods to compute the motion of an object from 2D image sequences and understand the process of the depth information from stereo images. | | | | | Analyse |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | 1 | 1 | | |
| CO2 | 3 | 2 | 2 | 2 | | |
| CO3 | 3 | 3 | 3 | 3 | | |
| CO4 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 3 | 2 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |

Syllabus

Module 1(8 Lectures)

Signals: Impulse Sequence - Exponential Sequence - Periodic Sequence. Linear Systems - Shift-Invariant systems - Linear Shift Invariant (LSI) systems – Convolution - Correlation. Image Transforms: Fourier Transform - Discrete Fourier Transform - Z- transform – KL Transform. Causal Systems - Random Signals - Stationary Process - Markov Process.

Module 2(10 Lectures)

Intensity Transformation and Spatial Filtering: Intensity Transformation Functions. Histogram Processing: Histogram Equalization - Histogram Matching. Image enhancement: Arithmetic/Logic operations - Image Subtraction - Image Averaging. Spatial Filtering:

Module 3 (8 Lectures)

Image degradation/Restoration process model - Noise probability density functions - Spatial Filtering: Mean Filters - Order-statistics filter - Adaptive Filters - Periodic Noise Reduction –Band-reject filters - Band-pass filters - Notch filters. Inverse filtering – Wiener

Module 4(10 Lectures)

Computer Vision: 3D structure from 2D images, Five frames of reference. Binary Image Analysis: Pixels and Neighborhoods, Applying masks to images, Counting the objects in an image, Connected components labeling. Binary image morphology, Region properties, Region adjacency graphs. Feature detection and matching: Points and patches, SIFT, SURF. Texture: Texture, Texels and Statistics, Texel based Texture Descriptions, Quantitative Texture Measures, Texture Segmentation.

Module 5 (8 Lectures)

Content based image retrieval: Image distance measures: Color similarity,Texture similarity, Shape similarity. Motion from 2D image sequences: Computing Motion Vectors. Matching in 2D: Registration of 2D data, Representation of points, Affine

References/Text Books

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 4th Ed., Pearson, March 2017.
2. Anil K.Jain, "Fundamentals of Digital Image Processing", Pearson, 1st Ed., 1988.
3. William K. Pratt, "Digital Image Processing: PIKS Scientific Inside", John Wiley & Sons, 4th Ed., 2007.
4. Azriel Rosenfeld, Avinash C. Kak, "Digital Picture Processing", Morgan Kaufmann, 2nd Ed., 1982.
5. Bernd Jahne, "Digital Image Processing", Springer, 6th Ed., 2005.
6. Linda G. Shapiro, George C. Stockman, "Computer Vision", Prentice Hall, 1st Ed., 2001.
7. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 1st Ed., 2010.
8. David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", 2nd Ed., 2011.
9. Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 1st Ed., 2012.
10. Ramesh Jain, RangacharKasturi, Brian G. Schunck, "Machine Vision", McGraw-Hill, 1st Ed., 1995.

| Semester 7 | | | | | | |
|--|--|------|------|------|-------------------------|--------|
| 24-813-0706 | SEMINAR (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | | 0 | 0 | 2 | 2 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Identify, read, and interpret an academic research article from the literature that is related to his/her academic area of interest and present it before the committee. | | | | Understand | |
| CO2 | Organize and communicate technical and scientific findings effectively in written and oral forms to technical and non-technical stakeholders. | | | | Analyze | |
| CO3 | Demonstrate the academic discussion skills to emphasize, argue with clarity of purpose using evidence for the claims. | | | | Apply | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | 1 | 1 | | |
| CO2 | 2 | 1 | 1 | 1 | | |
| CO3 | 1 | 1 | 1 | 1 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| The student has to prepare and deliver a presentation on a research topic suggested by the department before the peer students and expert committee. They also have to prepare a comprehensive report of the seminar presented | | | | | | |

| Semester 8 | | | | | | |
|--|---|------|------|------|---|-------------------|
| 24-813-0801 | Bioinformatics (Course Level 400-499) | TYPE | L | T | P | CREDI T |
| | | DSC | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand and appreciate basic concepts of molecular Biology and Human genome project. | | | | | Understand |
| CO2 | Illustrate and explain various sequence alignment algorithms. | | | | | Apply |
| CO3 | Demonstrate and evaluate different algorithms for identifying optimal phylogenetic trees. | | | | | Analyze |
| CO4 | Understand the concepts of structure prediction in molecular biology | | | | | Understand |
| CO5 | Understand and demonstrate an algorithm in the literature for the domain. | | | | | Analyze |
| CO- PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 1 | 1 | - | | |
| CO2 | 3 | 2 | 1 | - | | |
| CO3 | 3 | 3 | 2 | - | | |

| | | | | |
|-----|---|---|---|---|
| CO4 | 3 | 2 | 2 | - |
| CO5 | 3 | 1 | 3 | 3 |

Syllabus

Module 1 (8 Lectures)

Bioinformatics introduction-Branches of bioinformatics-Basic concepts of molecular Biology Proteins-Nucleic acids– genes and genetic synthesis – translation- transcription- protein SynthesisChromosomes- Maps and sequences- Biological databases

Module 2 (8 Lectures)

Sequence alignment-Concepts of alignment-Gap Penalty-Pairwise sequence alignment algorithms Dot Matrix-Global & Local alignment-Multiple sequence alignment algorithms-Scoring matrices PAM, BLOSUM-Heuristic Methods -BLAST-FASTA

Module 3 (8 Lectures)

Fragment Assembly of DNA - Biological Background-human genome project – Models -Algorithms - Heuristics - Physical Mapping of DNA - Internal Graph Models – Hybridization Mapping - Heuristics - Genome rearrangements-Oriented Blocks- unoriented Blocks

Module 4 (8 Lectures)

Molecular Phylogeny-Phylogenetic Trees –Methods of phylogeny-Maximum Parsimony-Maximum Likelihood-Distance methods-Binary Character States- Perfect phylogeny

Module 5 (8 Lectures)

Molecular Structure Prediction- Secondary structure prediction-Protein Folding problems-Protein threading-Computing with DNA-Hamilton Path Problems-Computer aided Drug design- peptide drug-chemical drug

References

1. Rastogi, S. C., Parag Rastogi, and Namita Mendiratta. Bioinformatics: Methods and ApplicationsGenomics, Proteomics and Drug Discovery. PHI Learning Pvt. Ltd., 5e, 2022.
2. Neil James and Pavel A Pevzner, An introduction to Bioinformatics Algorithms, 4e, OUPress, 2014
3. ZhumurGhosh, BibekanandMallick , Bioinformatics : Principles and Applications, OUPress, 2015

4. Concord Bessant, Darren Oakley, Ian Shadforth, Building Bioinformatics Solutions, OUPress, 2014
5. Peter Clote and Rolf Backofen, Computational Molecular Biology-An introduction, 1e, Wiley Series, 2000

| Semester 8 | | | | | | |
|--|---|------|------|------|----|---------------|
| 24-813-0802 | Research Project (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 0 | 0 | 12 | 12 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Identify technology/research gaps and propose creative solutions | | | | | Create |
| CO2 | Create solutions to real world problems by performing requirement analysis and identification of design methodologies | | | | | Create |
| CO3 | Function effectively as an individual and as a leader in diverse teams to plan and execute project utilizing available resources within timelines, following ethical and professional norms | | | | | Apply |
| CO4 | Organise and communicate technical and scientific findings effectively in written and oral forms | | | | | Apply |
| CO - PSO Mapping | | | | | | |
| CO | PSO 1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 2 | 3 | 3 | 1 | | |
| CO2 | 3 | 2 | 3 | 1 | | |
| CO3 | 1 | 1 | 2 | 3 | | |
| CO4 | 2 | 3 | 2 | 1 | | |
| <p>The course 'Project Work' is mainly intended to evoke the research, innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation.</p> <p>The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. The students should record in the daily/weekly activity diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the review, design and all the observations made by the student and guide. The diary shall be signed every week by the guide</p> | | | | | | |

| Semester 8 | | | | | | |
|---|--|------|-------------------------|------|---|--------|
| 24-813-0803 | Full Stack AI Lab (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | LAB | 0 | 0 | 2 | 2 |
| Course Outcomes (CO) | | | Revised BT Level | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Gain practical experience across the Full Stack AI development lifecycle | | Analyse | | | |
| CO2 | Master data engineering, preprocessing, and deploying AI models | | Apply | | | |
| CO3 | Develop secure, cross-platform applications and complete a capstone project demonstrating acquired skills. | | Create | | | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 3 | 3 | | |
| CO2 | 3 | 2 | 3 | 3 | | |
| CO3 | 3 | 2 | 3 | 3 | | |
| Indicative Experiments | | | | | | |
| <ol style="list-style-type: none"> 1. Implement a program for data source exploration. 2. Implement a program for data cleaning and preprocessing. 3. Implement a program for data analysis and feature Engineering. 4. Implement different supervised learning models and evaluate its performance. 5. Implement different unsupervised learning models and evaluate its performance. | | | | | | |

6. Implement the different model optimization techniques
7. Implement a simple deep learning model and saving as well as loading models.
8. Building Mobile Libraries (iOS/Android).
9. Cross-Platform Model Deployment.
10. Building Web /Mobile UIs with a backend API for data processing.
11. Creating Web Services (RESTful API)
12. Continuous Integration and Deployment
13. Implement the security best practices in Full Stack AI
14. Implement a capstone project to develop a real-world Full Stack AI application.

| Semester 8 | | | | | | |
|--|--|------|------|------|-------------------|--------|
| 24-813-0804 | Advanced Optimization Techniques (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSE | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to :</i> | | | | | | |
| CO1 | Understand the basic concepts of optimization and its applications. | | | | Understand | |
| CO2 | Understand the mathematical representation and classical methods for solving optimization | | | | Understand | |
| CO3 | Explain and demonstrate working principles of various population-based optimization techniques | | | | Apply | |
| CO4 | Explain and demonstrate working principle of various Hybrid Algorithms for optimization | | | | Apply | |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 2 | - | | |
| CO3 | 3 | 2 | 1 | - | | |
| CO4 | 3 | 3 | 3 | 2 | | |
| Syllabus | | | | | | |
| Module 1(8 Lectures) | | | | | | |
| Introduction to optimization- formulation of optimization problems-Review of classical methods-Linear programming- Nonlinear programming-Constraint optimality criteria constrained optimization-Population based optimization techniques. | | | | | | |
| Module 2(8 Lectures) | | | | | | |
| Genetic Algorithm - Introduction - Working principle - Representation - selection – fitness assignment - reproduction - crossover - mutation - constraint handling -advanced genetic algorithms - Applications - Artificial Immune Algorithm - Introduction- Clonal selection algorithm- Negative selection algorithm - Immune network algorithms - Dendritic cell algorithms. | | | | | | |

Module 3(8 Lectures)

Differential Evolution - Introduction - Working principles - parameter selection - advanced algorithms in Differential evolution - Biogeography-based Optimization - Introduction - Working Principles - Algorithmic variations.

Module 4(8 Lectures)

Particle Swarm Optimization-Introduction- Working principles- Parameter selection Neighborhoods and Topologies-Convergence-Artificial Bee Colony Algorithm-Introduction Working principles- Applications-Cuckoo search based algorithm-Introduction- Working principles- Random walks and the step size-Modified cuckoo search.

Module 5(8 Lectures)

Hybrid Algorithms-Concepts- divide and conquer- decrease and conquer-HPABC-HBABC- HDABC- HGABC-Shuffled Frog Leaping Algorithm - Working principles - Parameters- Grenade Explosion Algorithm-Working principle-Applications

References

1. Dan Simon, Evolutionary Optimization Algorithms, 1e, Wiley, 2013
2. Xin-She Yang, Engineering Optimization: An Introduction with Meta-heuristic Applications, 1e, Wiley, 2010
3. S.S. Rao, Engineering Optimization: Theory and Practice, 4e, New Age International, 2013
4. R. VenkataRao, Teaching Learning Based Optimization Algorithm: And Its Engineering Applications, 1e, Springer, 2016

| Semester 8 | | | | | | |
|---|--|------|------|------|---|-------------------|
| 24-813-0805 | Blockchain Technology (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSE | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamentals of blockchain technology | | | | | Understand |
| CO2 | Understand the essentials of Bitcoin and beholding bitcoins as blockchains | | | | | Understand |
| CO3 | Analyze and design the Ethereum Blockchain | | | | | Analyze |
| CO4 | Analyze the powers of blockchains and their applications in various | | | | | Analyze |
| CO5 | Execute a mini project on blockchain | | | | | Apply |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 2 | - | | |
| CO3 | 3 | 2 | 1 | - | | |
| CO4 | 3 | 3 | 3 | 2 | | |
| Syllabus | | | | | | |
| Module 1(8 Lectures) | | | | | | |
| Introduction to blockchain: Structure of blockchains, Blockchain life cycle, working of a blockchain, picking a blockchain, exploring blockchain applications, building trust with blockchains, Blockchain in action: Use cases, introducing bitcoin blockchains. | | | | | | |
| Module 2(10 Lectures) | | | | | | |
| Bitcoin & Ethereum blockchains: Understanding bitcoins, comprehending bitcoins as blockchains, analyzing Ethereum blockchains, introducing ripple and factom blockchains and their importance | | | | | | |
| Module 3 (8 Lectures) | | | | | | |

Powerful blockchain platforms: Getting introduced to Hyperledger, Hyperledger vision, Hyperledger sawtooth, understanding the blockchain fabric, understanding business, and smart blockchains, IBM Blockchains, Stellar: an optimized blockchain

Module 4(10 Lectures)

Industry impacts of blockchains: Blockchains in financial technology, Blockchains in various industries such as insurance, Government, Real-estate, health care, Telecommunication, Transportation, etc..

Module 5 (8 Lectures)

Case Study and mini-project: Study different blockchain projects as a case study and submit a report and present the work, design a blockchain application as a mini-project, and presenting the work.

References

1. Blockchain and Crypto Currency, Editors: Makoto YanoChris DaiKenichi MasudaYoshio Kishimoto, 1st Edition, Springer, 2020.
2. Blockchain or Dummies, Tiana Laurence, 1st Edition , John Wiley & Sons, Inc, , 2017.
3. Blockchain Blueprint for a new economy, Melanie Swan, 1st Edition,O'Reilly, 2017.
4. Blockchain Technology: Applications and Challenges, Panda, S.K., Jena, A.K., Swain, S.K., Satapathy, S.C. , 1st Edition, Springer, 2021
5. Blockchain and Distributed Ledgers, Alexander Lipton and Adrien Treccani, 1st Edition, World Scientific Press, 2021

| Semester 8 | | | | | | |
|--|--|------|------|------|---|-------------------|
| 24-813-0806 | Information Retrieval and Web Search (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSE | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand advanced techniques for text-based information retrieval. | | | | | Understand |
| CO2 | Understand Boolean and vector space retrieval models | | | | | Understand |
| CO3 | Evaluate various text classification techniques | | | | | Evaluate |
| CO4 | Understand Web search characteristics, web crawling and link analysis | | | | | Understand |
| CO5 | Build working systems that assist users in finding useful information on the Web | | | | | Apply |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 2 | - | | |
| CO3 | 3 | 2 | 1 | - | | |
| CO4 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 3 | 2 | | |
| Syllabus | | | | | | |
| Module 1(8 Lectures) | | | | | | |
| Taxonomy of IR Models – Classic models- Set theoretic model- Algebraic models- Probabilistic model Structured text retrieval models- Models for browsing- Retrieval evaluations-Reference collections | | | | | | |
| Module 2(8 Lectures) | | | | | | |
| Query languages-query operations-text and multimedia languages-Text operations-document preprocessing- matrix decompositions and latent semantic indexing-text compression –indexing and searching-inverted files- suffix trees- Boolean queries-sequential searching-pattern matching | | | | | | |
| Module 3(8 Lectures) | | | | | | |

Text Classification, and Naïve bayes-vector space classification-support vector machines and machine learning on documents-flat clustering –hierarchical clustering

Module 4(8 Lectures)

Web search basics-web characteristics-index size and estimation- near duplicates and shingling-web crawling-distributing indexes- connectivity servers-link analysis-web as a graph- PageRank-Hubs and authorities-question answering

Module 5(8 Lectures)

Online IR systems- online public access catalogs-digital libraries-architectural issues-document models - representations and access- protocols

References

1. Ricardo Baezce Yates, BerthierRibeiro-Neto , Modern Information Retrieval: The Concepts and Technology behind Search, 3e, ACM Press, 2017
2. Christopher D. Manning, PrabhakarRaghavan and HinrichSchütze , Introduction to Information Retrieval, 1e, Cambridge University Press, 2008
3. Bruce Croft, Donald Metzler and Trevor Strohman, Search Engines: Information Retrieval in Practice, 1e, AW, 2009

| Semester 8 | | | | | | |
|--|--|------|---|---|---|-------------------|
| 24-813-0807 | Number Theory and Cryptography (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSE | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to :</i> | | | | | | |
| CO1: Understand the fundamental principles of number theory and their applications in cryptography. | | | | | | |
| CO2: Apply modular arithmetic concepts to solve cryptographic problems and analyze cryptographic algorithms. | | | | | | |
| CO3: Demonstrate proficiency in basic cryptographic techniques, including symmetric and asymmetric encryption, hash functions, and cryptographic protocols. | | | | | | |
| CO4: Evaluate the security of cryptographic systems using number theory-based concepts such as primality testing and factorization algorithms. | | | | | | |
| CO5: Design and implement cryptographic solutions using advanced cryptographic techniques, including elliptic curve cryptography, digital signatures, and zero-knowledge proofs. | | | | | | |
| CO6: Analyze and critique cryptographic protocols and their applications in secure communication, digital signatures, and authentication. | | | | | | |
| CO7: Investigate emerging cryptographic technologies such as blockchain, quantum cryptography, and their impact on the future of secure communication and data protection. | | | | | | |
| CO8: Develop critical thinking and problem-solving skills through practical exercises, assignments, and a final project that integrates theoretical knowledge with real-world applications in cryptography | | | | | | |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamental principles of number theory and their applications in cryptography. | | | | | Understand |
| CO2 | Apply modular arithmetic concepts to solve cryptographic problems and analyze cryptographic algorithms. | | | | | Analyze |
| CO3 | Demonstrate proficiency in basic cryptographic techniques, including symmetric and asymmetric encryption, hash functions, and cryptographic protocols. | | | | | Apply |

| | | |
|-----|---|---------------------|
| CO4 | Evaluate the security of cryptographic systems using number theory-based concepts such as primality testing and factorization algorithms. | Evaluate |
| CO5 | Design and implement cryptographic solutions using advanced cryptographic techniques, including elliptic curve cryptography, digital signatures, and zero-knowledge proofs. | Apply |
| CO6 | Analyze and critique cryptographic protocols and their applications in secure communication, digital signatures, and authentication. | CO6: Analyze |
| CO7 | Investigate emerging cryptographic technologies such as blockchain, quantum cryptography, and their impact on the future of secure communication and data protection. | Evaluate |
| CO8 | Develop critical thinking and problem-solving skills through practical exercises, assignments, and a final project that integrates theoretical knowledge with real-world applications in cryptography | Analyze |

CO - PSO Mapping

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|------|------|
| CO1 | 3 | 2 | 2 | - |
| CO2 | 3 | 3 | 2 | - |
| CO3 | 3 | 2 | 1 | - |
| CO4 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 2 | 2 | - |
| CO7 | 3 | 3 | 2 | - |
| CO8 | 3 | 3 | 2 | - |

Syllabus

Module 1(8 Lectures)

Finite Fields: Groups, Rings and Fields. Overview of Number Theory: Introduction to prime numbers, composite numbers, and basic divisibility properties, greatest common divisor (GCD), and least common multiple (LCM). Modular Arithmetic: Understanding modular arithmetic, congruences, and

arithmetic operations modulo n . Prime Numbers: Properties of prime numbers, prime factorization, and fundamental theorems of arithmetic, Primality testing and factorization.

Module 2(10 Lectures)

Fermat's Little Theorem and Euler's Totient Function: Understanding their applications in cryptography, especially in RSA encryption and decryption. Diffie-Hellman Key Exchange: Principles and protocols of key exchange based on number theory concepts. Primality Testing: Introduction to primality testing algorithms, including probabilistic and deterministic methods. Cryptanalysis Techniques: Basic cryptanalysis techniques such as frequency analysis and brute force attacks. Quadratic Residues & Arithmetic Functions: Quadratic Residues- Quadratic Congruences, The group of Quadratic residues, Legendre symbol, Jacobi Symbol, Quadratic reciprocity.

Module 3 (8 Lectures)

Introduction to Cryptography: History, evolution, and importance of cryptography. Symmetric Encryption: Principles of symmetric key encryption, substitution ciphers, and transposition ciphers. Asymmetric Encryption: Concepts of asymmetric key encryption, RSA algorithm, and public-key cryptography. Cryptographic Hash Functions: Understanding hash functions, properties, and applications in digital signatures and data integrity.

Module 4(10 Lectures)

Elliptic Curve Cryptography: Introduction to elliptic curve cryptography, elliptic curve operations, and applications in modern cryptographic systems. Digital Signatures: Principles of digital signatures, digital signature schemes, and applications in authentication and non-repudiation. Zero-Knowledge Proofs: Overview of zero-knowledge proofs, protocols, and their applications in cryptographic protocols like secure authentication and identification.

Module 5 (8 Lectures)

Secure Communication Protocols: Overview of secure communication protocols such as SSL/TLS, SSH, and IPsec. Cryptographic Applications: Real-world applications of cryptography in secure messaging, online transactions, and digital certificates. Blockchain and Cryptocurrency: Introduction to blockchain technology, cryptographic principles in blockchain consensus mechanisms, and cryptocurrency fundamentals. Quantum Cryptography: Basics of quantum cryptography, quantum key distribution, and implications for future cryptographic systems.

References

1. Ivan Niven, Herbert S. Zuckerman, Hugh L. Montgomery - "Introduction to the Theory of Numbers" (Wiley, 5th Edition, 1991)
2. David M. Burton - "Elementary Number Theory" (McGraw-Hill Education, 7th Edition, 2010)

3. Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman - "An Introduction to Mathematical Cryptography" (Springer, 2nd Edition, 2014)
4. William Stallings - "Cryptography and Network Security: Principles and Practice" (Pearson, 7th Edition, 2016)
5. Christof Paar, Jan Pelzl - "Understanding Cryptography: A Textbook for Students and Practitioners" (Springer, 3rd Edition, 2010)
6. Lawrence C. Washington - "Elliptic Curves: Number Theory and Cryptography" (Chapman and Hall/CRC, 2nd Edition, 2008).
7. Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone - "Handbook of Applied Cryptography" (CRC Press, 1st Edition, 1996)

| Semester 8 | | | | | | |
|--|---|------|------|------|-------------------|--------|
| 24-813-0808 | Large Language Models (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSE | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the architecture and functioning of Large Language Models (LLM). | | | | Understand | |
| CO2 | Fine-tune pre-trained language models for various NLP tasks using Deep Learning tools | | | | Apply | |
| CO3 | Design and generate prompts for generative LLMs to solve real-world challenges. | | | | Analyze | |
| CO4 | Critically assess the ethical implications and societal impact of using LLMs. including elliptic curve cryptography, digital signatures, and zero-knowledge proofs. | | | | Evaluate | |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 2 | - | | |
| CO2 | 3 | 3 | 2 | - | | |
| CO3 | 3 | 2 | 1 | - | | |
| CO4 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 3 | 2 | | |
| Syllabus | | | | | | |
| Module 1(8 Lectures) | | | | | | |
| Large Language Models (LLM) - Introduction, Evolution of LLM, Foundation models & Instruction following LLM; Pre-training & Transfer learning; Solving Natural Language Processing (NLP) tasks using LLMs. | | | | | | |
| Module 2(10 Lectures) | | | | | | |
| Transformers - Encoder-Decoder models, Attention Mechanism; Architecture - Self-attention, Multihead attention, Layer Normalization, Positional encoding; Pre-training and fine-tuning of | | | | | | |

Transformer based models - Autoregressive models (BERT), Generative model (GPT) and Sequence to sequence model (T5)

Module 3 (8 Lectures)

Tokenization techniques - Word & Sub-word modeling, Viterbi algorithm, Wordpiece tokenizer, Sentencepiece tokenizer, Byte Pair Encoding (BPE); Text Embeddings - Searching, classification, Clustering; Similarity Between Words and Sentences; Semantic Search

Module 4(8 Lectures)

Prompt Engineering - Introduction to Generative AI, Prompt design, Types of Prompting; Controlling model output via parameters; Use Case Ideation, Creating Custom Generative Models, Chain-ofThought Prompting, Prompt Attacks and Mitigation.

Module 5 (8 Lectures)

Ethical and Societal Implications of LLMs - Bias and Fairness, Privacy concerns, Ethical considerations, Misinformation, and Disinformation challenges, Mitigation strategies; Case study: Application of LLMs in various domains. Mini Project - Building applications from pre-trained LLMs for real-world scenarios.

References

1. Bommasani, Rishi, et al. "On the opportunities and risks of foundation models.", Center for Research on Foundation Models (CRFM), Stanford Institute for Human-Centered Artificial Intelligence (HAI), Stanford University.
2. Rogers, Anna, Olga Kovaleva, and Anna Rumshisky. "A primer in BERTology: What we know about how BERT works." Transactions of the Association for Computational Linguistics 8 (2021): 842-866.
3. Lin, Jimmy, et al. Pretrained Transformers for Text Ranking: BERT and Beyond. United States, Morgan & Claypool Publishers, 2021.
4. Pal, Ankit. "Promptify: Structured Output from LLMs." (2022) available at <https://github.com/prompts-lab/Promptify>

| Semester 8 | | | | | | |
|---|---|------|------|------|-------------------------|--------|
| 24-813-0811 | Mini Project – 2 (Course Level 400-499) | TYPE | L | T | P | CREDIT |
| | | DSC | 0 | 0 | 4 | 4 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Create innovative solutions to real world problems by applying advanced programming techniques with requirement analysis and identification of design methodologies | | | | Apply | |
| CO2 | Function effectively as an individual and as a leader in diverse teams to plan and execute project utilizing available resources within timelines, following ethical and professional norms | | | | Apply | |
| CO3 | Organize and communicate technical and scientific findings effectively in written and oral forms | | | | Analyze | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 3 | 3 | 1 | | |
| CO2 | 3 | 2 | 3 | 3 | | |
| CO3 | 2 | 3 | 3 | 2 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation | | | | | | |
| <p>The objective of this course is to apply the fundamental concepts of Software Engineering principles for the effective development of an application/research project. This course helps the learners to practice the different steps to be followed in the software development process such as literature review and problem identification, preparation of Software Requirement Specification & Software Design Document (SDD), testing, development and deployment.</p> <p>Guides are allotted at the beginning of the semester. A team consists of only one student. Student should identify a topic of interest in consultation with the Guide, review the literature and gather information pertaining to the chosen topic.</p> | | | | | | |

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. The students should record in the daily/weekly activity diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the review, design and all the observations made by the student and guide. The diary shall be signed every week by the guide.

The progress of the mini project is evaluated based on a minimum of two reviews by the committee. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester.

Preparing a paper for Conference/Publication in Journals is desirable for the successful completion of course. Students are also encouraged to present projects in Project Expos conducted at state level as well as others conducted in India and abroad

| Semester 9 | | | | | | |
|---|---|------|------|------|----|----------------|
| 24-813-0901 | Major Project Phase 1 (Course Level 500-599) | TYPE | L | T | P | CREDIT |
| | | DSC | 0 | 0 | 14 | 14 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Identify technology/research gaps and propose creative solutions | | | | | Analyze |
| CO2 | Create solutions to real world problems by performing requirement analysis and identification of design methodologies | | | | | Apply |
| CO3 | Function effectively as an individual and as a leader in diverse teams to plan and execute project utilizing available resources within timelines, following ethical and professional norms | | | | | Apply |
| CO4 | Organize and communicate technical and scientific findings effectively in written and oral forms | | | | | Apply |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 2 | 3 | 3 | 1 | | |
| CO2 | 3 | 2 | 3 | 1 | | |
| CO3 | 1 | 1 | 2 | 3 | | |
| CO4 | 2 | 3 | 2 | 1 | | |
| <p>The course 'Project Work' is mainly intended to evoke the research, innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 9th and 10th semester separately, based on the achieved objectives. Importance should be given to address societal problems and developing indigenous technologies</p> <p>The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. The students should record in the daily/weekly activity diary the day-to-day account of</p> | | | | | | |

the observations, impressions, information gathered and suggestions given, if any. It should contain the review, design and all the observations made by the student and guide. The diary shall be signed every week by the guide

Phase 1 Target

- Literature study/survey of published literature on the assigned topic
- Formulation of objectives
- Formulation of hypothesis/ design/ methodology
- Formulation of work plan and task allocation.
- Block level design documentation
- Preliminary Design and Feasibility study

Students may be permitted to do the Final Year Project from top Universities in India and abroad upon getting the approval from Department Council

| Semester 10 | | | | | | |
|---|---|-------------|-------------|-------------|----|----------------|
| 24-813-1001 | Major Project Phase 2 (Course Level 600-699) | TYPE | L | T | P | CREDIT |
| | | DSC | 0 | 0 | 22 | 22 |
| Course Outcomes (CO) | | | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Create innovative solutions to real world problems by applying advanced programming techniques with requirement analysis and identification of design methodologies | | | | | Analyze |
| CO2 | Function effectively as an individual and as a leader in diverse teams to plan and execute project utilizing available resources within timelines, following ethical and professional norms | | | | | Apply |
| CO3 | Organize and communicate technical and scientific findings effectively in written and oral forms. | | | | | Apply |
| CO - PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | 3 | 1 | | |
| CO2 | 1 | 1 | 2 | 3 | | |
| CO3 | 2 | 3 | 2 | 1 | | |
| <p>The course 'Project Work' is mainly intended to evoke the research, innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 9th and 10th semester separately, based on the achieved objectives.</p> <p>Phase 2 Targets</p> <ul style="list-style-type: none"> ● Final development of product/ process, testing, results, conclusions and future directions. ● Preparing a paper for Conference Presentation/ Publication in Journals, | | | | | | |

- Presenting projects in Project Expos conducted at state level as well as others conducted in India and abroad.
- Preparing a report in the standard format for being evaluated by the evaluation committee
- Final project presentation and viva-voce by the committee

MULTIDISCIPLINARY COURSES

Semester 1

| | | | | | | |
|--|--|--------|---|------|------------------|--------|
| 24-813-0103 | Computational Thinking for problem solving (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | CS MDC | 3 | 1 | 0 | 3 |
| Course Outcomes (CO) | | | | | Revised BT Level | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Recognizing and Defining Computational Problems | | | | Understand | |
| CO2 | Designing algorithms for simple problems using computational thinking principles | | | | Apply | |
| CO3 | Applying inductive and deductive reasoning, and Boolean logic to solve problems | | | | Apply | |
| CO4 | Designing solutions and solution processes based on problem definitions. | | | | Apply | |
| CO5 | Programming CT artifacts using Python | | | | Analyze | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | | PSO3 | | |
| CO1 | 3 | - | | - | | |
| CO2 | 3 | 2 | | 3 | | |
| CO3 | 3 | 3 | | 1 | | |
| CO4 | 1 | 3 | | 3 | | |
| CO5 | - | 3 | | 2 | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation | | | | | | |

Syllabus

Module 1

Elements of Computational Thinking - Understanding computational thinking - Decomposing problems, Recognizing patterns, Generalizing patterns, Designing algorithms for simple problems

Module 2

Understanding Algorithms and Algorithmic Thinking - Defining algorithms in depth, Designing algorithms, Analyzing algorithms - Big-Oh notation.

Module 3

Understanding Logical Reasoning - Inductive reasoning, Deductive reasoning. Using Boolean logic and operators. Identifying Logical Errors and Debugging. Understanding the problem definitions - Learning how to decompose problems - Converting the flowchart into an algorithm. Designing Solutions and Solution Processes

Module 4

Identifying Challenges within Solutions - Identifying errors in algorithm design - Debugging algorithms -Comparing solutions - Refining and redefining solutions

Module 5

Introduction to Python, Using Computational Thinking in Simple Challenges, Using Python in Experimental and Data Analysis Problems - Classification and Clusters, Using Computational Thinking and Python in Statistical Analysis

References

1. Applied Computational Thinking with Python - Second Edition. By Sofía De Jesús, Dayrene Martinez
2. Karl Beecher, Computational Thinking – A beginners guide to problem solving and programming, BCS, 1e, THE CHARTERED INSTITUTE FOR IT, 2017
3. Peter J. Denning, Matti Tedre, Computational Thinking, MIT Press, 2019
4. Peter William Mcowan, Paul Curzon, Power Of Computational Thinking, World Scientific, 2017

| Semester 2 | | | | | | |
|--|---|-------------------|---|-----------------------------|---|--------|
| 24-813-0203 | Foundations of Programming (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | CS MDC | 3 | 1 | 0 | 3 |
| Course Outcomes (CO) | | | | Revised BT Level | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the fundamentals of programming and learn to write programs. | Understand | | | | |
| CO2 | Analyze the different the programming structures such as decision making statements, loops, arrays and functions. | Analyze | | | | |

| | | |
|-----|---|-------------------|
| CO3 | Understand the basic concepts of OOP and learn how to create and initialize objects using constructors. | Understand |
| CO4 | Understand and analyze the different types of inheritance. | Understand |
| CO5 | Understand the usage of polymorphism, template classes, namespaces and exception handling | Understand |

CO – PSO Mapping

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|----------|------|
| CO1 | 3 | 2 | - | - |
| CO2 | 3 | 2 | - | - |
| CO3 | 3 | 2 | 1 | - |
| CO4 | 3 | 2 | 1 | - |
| CO5 | 3 | 2 | 1 | - |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation

Syllabus

Module 1(8 Lectures)

Introduction to Programming: Basic Difference between Procedure Oriented Language and Object Oriented Language. Fundamentals of C: Features of C language, structure of C program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions.

Module 2(10 Lectures)

Simple statements, Decision making statements, Looping statements, Nesting of control structures, break and continue statement. Array & String: Concept of array, One and Two

dimensional arrays, declaration and initialization of arrays, String, String storage, Built-in string functions.

Module 3 (8 Lectures)

Functions: Concept of user defined functions, prototype, definition of function, parameters, parameter passing, calling a function

Module 4(10 Lectures)

Introduction to OOP: Basic properties, Classes and Objects, Member functions and variables, Abstract data types (ADT), Encapsulation. Constructors: Parameterized Constructors, Copy Constructors, Dynamic Constructors, Destructors.

Module 5 (8 Lectures)

Inheritance and Access Control: Member access control in classes, Friend functions and classes, Public Private and Protected Inheritance, Polymorphism: Runtime and compile time polymorphism, overloading functions and operators, Defining Operator Overloading

References

1. Yashavant Kanetkar: Let Us C, 15e,BPB Publications, 2016.
2. Herbert Schildt: C: The Complete Reference, 4e, McGraw Hill Education, 2017.
3. Pradip Dey, Manas Ghosh: Computer Fundamentals and Programming in C, 2e, Oxford University Press, 2013.
2. Bjarne Stroustrup: C++ Programming Language, 4e, Addison-Wesley, 2013.
3. Bjarne Stroustrup: Programming: Principles and Practice Using C++, 2e, Addison- Wesley, 2014.
4. Stanley Lippman, Josée Lajoie, Barbara Moo: C++ Primer, 5e, Addison-Wesley, 2012.
5. Paul Deitel, Harvey Deitel: C++ How to Program, 10e, Pearson, 2016.
6. Timothy Budd: Introduction To Object-Oriented Programming, Pearson Education, 2008.
7. Walter J. Savitch, Kenrick Mock: Problem Solving with C++, 9e, Pearson Education, 2017.
8. Ira Pohl: Object-Oriented Programming Using C++, 2e, Addison-Wesley,1996.

| Semester 3 | | | | | | |
|--|--|-------------------|---|-------------------------|---|--------|
| 24-813-0303 | Fundamentals of Data Structures (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | CS MDC | 3 | 1 | 0 | 3 |
| Pre-requisites: 24-813-0103, 24-813-0203 | | | | | | |
| Course Outcomes (CO) | | | | Revised BT Level | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the basic concepts of programming | Understand | | | | |
| CO2 | Use elementary and advanced data structures such as Array, Linked list, Tree and to solve real world problems efficiently. | Apply | | | | |
| CO3 | Implement searching and sorting methods. | Apply | | | | |
| CO4 | Implement object oriented concepts in programming | Apply | | | | |

CO – PSO Mapping

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|------|------|
| CO1 | 3 | 2 | 1 | - |
| CO2 | 3 | 2 | 1 | - |
| CO3 | 3 | 2 | 1 | - |
| CO4 | 3 | 2 | 1 | - |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1

Introduction to programming methodologies – structured approach, stepwise refinement techniques, programming style, documentation. Elementary data organization - Data structure - Data structure operation, Review of basic programming questions

Module 2

Array, Records and Pointers: Introduction, Linear array, Representation of linear array in memory, Traversing linear array, Inserting and Deleting, Sorting methods, Searching methods.

Module 3

String - representation of strings, concatenation, substring searching and deletion.

Linked List: Introduction, Linked list, Representation of Linked list in memory, Searching a linked list,

Module 4

Stacks, Queues, Recursion - Introduction, Stacks, Queues, Operations on stacks and Queues, Implementation of Stacks and Queues using arrays and linked list, Applications.

Module 5

Tree - Introduction, Terminology of Binary tree, Types of Binary tree, Traversing of binary tree,

References

1. Samanta D.: Classic Data Structures, 2e, Prentice Hall India, 2009.
2. Richard F. Gilberg, Behrouz A. Forouzan: Data Structures: A Pseudocode Approach with C, 2e, Cengage Learning, 2005.
3. Aho A. V., J. E. Hopcroft, J. D. Ullman: Data Structures and Algorithms, Pearson Publication, 1983.
4. Tremblay J. P., P. G. Sorenson: Introduction to Data Structures with Applications, 2e, Tata McGraw Hill, 1995.
5. Peter Brass: Advanced Data Structures, Cambridge University Press, 2008.
6. Lipschutz S.: Theory and Problems of Data Structures, Schaum's Series, 1986.
7. Wirth N.: Algorithms + Data Structures = Programs, Prentice Hall, 2004.
8. Horwitz E., S. Sahni, S. Anderson: Fundamentals of Data Structures in C, University Press (India), 2008.

MINOR COURSES

| Semester 1 | | | | | | |
|--|--|-------------------------|---|---|---|--------|
| 24-813-0101 | Computational Thinking for Problem Solving (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | MIN | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | Revised BT Level | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Recognizing and Defining Computational Problems | Understand | | | | |
| CO2 | Designing algorithms for simple problems using computational thinking principles | Apply | | | | |
| CO3 | Applying inductive and deductive reasoning, and Boolean logic to solve problems | Apply | | | | |
| CO4 | Designing solutions and solution processes based on problem definitions. | Apply | | | | |

| | | |
|-----|--|----------------|
| CO5 | Testing and Refining Computational Artifacts | Analyze |
|-----|--|----------------|

CO – PSO Mapping

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|------|------|
| CO1 | 3 | - | - | - |
| CO2 | 3 | 2 | 3 | - |
| CO3 | 3 | 3 | 1 | - |
| CO4 | 1 | 3 | 3 | - |
| CO5 | - | 3 | 2 | - |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation

Syllabus

Module -1 (8 Lectures)

Elements of Computational Thinking - Understanding computational thinking - Decomposing problems, Recognizing patterns, Generalizing patterns, Designing algorithms for simple problems

Module 2(8 Lectures)

Understanding Algorithms and Algorithmic Thinking - Defining algorithms in depth, Designing algorithms, Analyzing algorithms.

Module 3 (8 Lectures)

Understanding Logical Reasoning - Inductive reasoning, Deductive reasoning. Using Boolean logic and operators. Identifying Logical Errors and Debugging

Module 4(8 Lectures)

Understanding the problem definitions - Learning how to decompose problems - Converting the flowchart into an algorithm. Designing Solutions and Solution Processes,

Module 5 (8 Lectures)

Identifying Challenges within Solutions - Identifying errors in algorithm design - Debugging algorithms -Comparing solutions - Refining and redefining solutions

References

1. Applied Computational Thinking with Python - Second Edition. By Sofía De Jesús, Dayrene Martinez
2. Karl Beecher, Computational Thinking – A beginners guide to problem-solving and programming, BCS, 1e, THE CHARTERED INSTITUTE FOR IT, 2017
3. Peter J. Denning, Matti Tedre, Computational Thinking, MIT Press, 2019
4. Peter William Mcowan, Paul Curzon, Power Of Computational Thinking, World Scientific, 2017

| Semester 1 | | | | | | |
|--|---|-------------------------|------|------|---|--------|
| 24-813-0102 | Practical Applications of AI (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | MIN | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | Revised BT Level | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understanding of AI Concepts | Understand | | | | |
| CO2 | Demonstrate knowledge of various AI algorithms, techniques, and models | Apply | | | | |
| CO3 | Apply AI techniques to solve real-world problems and demonstrate critical thinking skills | Apply | | | | |
| CO4 | Understand knowledge-based systems. | Understand | | | | |
| CO5 | Know ethical concerns | Understand | | | | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |

| | | | | |
|-----|---|---|---|---|
| CO1 | 3 | - | - | - |
| CO2 | 3 | 2 | 2 | - |
| CO3 | 3 | 2 | 2 | - |
| CO4 | 3 | - | 2 | - |
| CO5 | - | 3 | 1 | 3 |

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

AI in Practice: Robotic Systems, Computer Vision, Natural Language Processing Education, Government, Healthcare, Technology, Commerce, Manufacturing, Agriculture

Module-2(10 Lectures)

Artificial Intelligence, Machine Learning, Neural Networks, Perceptron, Deep Learning, Explainable AI, Generative AI, Prompt Engineering, GPT

Module-3 (8 Lectures)

Familiarisation of AI Software Python, R, Google Colab, Anaconda, UIPath, Power BI.

Practical Generative AI Examples, Creating presentations, Opening Excel files and draw graphs automatically, Make new pictures and music.

Module-4(8 Lectures)

Ethical concerns raised by AI, The role of ethics in the development of AI, Different ways of operationalizing fairness in the context of AI, Transparency and AI systems, AI and the Sustainable Development Goals, Applying AI to address the SDGs, The positive and negative impact of AI on the SDGs

Module-5 (6 Lectures)

Case Study 1: Contributions of AI towards developing vaccines

Case Study 2: AI for disaster management

References

1. Artificial Intelligence and Machine Learning by Vinod Chandra S. S and Anand Hareendran S, PHI, 2014.
2. Machine Learning: The New AI by Ethem Alpaydin, The MIT Press, 2016
3. <https://microsoft.github.io/AI-For-Beginners/> Introduction to AI, Evolution of AI, Turing test, Categories of AI, Applications of AI, Problem Definition as a State Space Search, Production System, Control Strategies Ethem Alpaydin, Machine Learning: The New AI, MIT Press, 2016

| Semester 2 | | | | | | |
|--|---|-------------------|-------------------------|---|---|--------|
| 24-813-0202 | Computer Fundamentals 1 (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | MIN | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | Revised BT Level | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understanding of the basic components of a computer system, including the CPU, memory, and storage | Understand | | | | |
| CO2 | Gain proficiency in using common operating systems such as Windows or Linux | Apply | | | | |
| CO3 | Acquire basic skills in computer programming and algorithmic thinking. | Apply | | | | |
| CO4 | Understand fundamental concepts of computer networking, including protocols, topologies, and network devices. | Understand | | | | |
| CO5 | Know ethical issues related to computer technology, including privacy, intellectual property, and social implications of automation | Understand | | | | |

CO – PSO Mapping

| CO | PSO1 | PSO2 | PSO3 | PSO4 |
|-----|------|------|----------|----------|
| CO1 | 2 | - | - | - |
| CO2 | 1 | - | - | - |
| CO3 | 3 | 2 | 1 | - |
| CO4 | 3 | 2 | 3 | - |
| CO5 | - | 2 | - | 3 |

Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation

Syllabus

Module -1(8 Lectures)

Introduction, Basic Applications of Computer, Components of Computer, Connecting Computer Components, Computer Hardware & Software. What is an Operating System, Basics of Popular Operating Systems.

Module-2(10 Lectures)

Word Processing: Introduction, Document Creation & Editing, Saving, Text Formatting. Microsoft Excel & using Spreadsheets: Introduction, Rows, Columns & Cells, Basics Excel Formulas and Functions

Module-3 (8 Lectures)

Introduction to Internet, WWW and Web Browsers: Basic of Computer networks; LAN, WAN; Concept of Internet; Applications of Internet; Connecting to Internet; What is ISP; Knowing the Internet; Basics of internet connectivity related troubleshooting, Search Engines; Understanding URL; Domain name and IP Address

Module-4(8 Lectures)

Communications and collaboration: Basics of electronic mail; Getting an email account; Sending and receiving emails; Accessing sent emails; Using Emails; Document collaboration; Instant Messaging; Netiquettes.

Module-5 (6 Lectures)

Computer Security and Privacy: Importance of Computer Security, Common Security Threats, Malware (Viruses, Worms, Trojans), Network Security Measures Firewalls, Encryption, Access Control, User Authentication, Privacy Concerns and Data Protection

References

1. Computer Basics Absolute Beginner's Guide- Michael Miller
2. Absolute Beginners Guide to Computing - Wallace Wang
3. Computer Fundamentals: Concepts, Systems & Applications- 8th Edition- Priti Sinha, Pradeep K, Sinha
4. Computers Made Easy from Dummy to Geek- James Bernstein

| Semester 2 | | | | | | |
|--|--|-------------------------|------|------|---|--------|
| 24-813-0201 | Fundamentals of programming (Course Level 100-199) | TYPE | L | T | P | CREDIT |
| | | MIN | 4 | 1 | 2 | 4 |
| Course Outcomes (CO) | | Revised BT Level | | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understand the programming fundamentals and write programs. | Understand | | | | |
| CO2 | Analyse the different programming structures such as decision-making statements, loops, arrays, and functions. | Analyze | | | | |
| CO3 | Understanding the basic concepts of OOP and learning how to create and initialize objects using constructors. | Understand | | | | |
| CO4 | Understand and analyze the different types of inheritance. | Understand | | | | |
| CO5 | Understand the usage of polymorphism, template classes, namespaces, and exception handling | Understand | | | | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 3 | 2 | - | - | | |
| CO2 | 3 | 2 | - | - | | |

| | | | | |
|-----|---|---|---|---|
| CO3 | 3 | 2 | 1 | - |
| CO4 | 3 | 2 | 1 | - |
| CO5 | 3 | 2 | 1 | - |

: Correlations Levels: 1 = Low, 2 = Medium, 3 = High, "-" = No correlation

Syllabus

Module 1(8 Lectures)

Introduction to Programming: Basic Difference between Procedure Oriented Language and Object Oriented Language, Concepts of Machine level, Assembly level and High-level programming, Flow charts and Algorithms.

Module 2(8 Lectures)

Fundamentals of C: Features of C language, structure of C program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions.

Module 3 (8 Lectures)

Simple statements, Decision-making statements, Looping statements, Nesting of control structures, break and continue statements. Array & String: Concept of array, One and Two-dimensional arrays, declaration and initialization of arrays, String, String storage, Built-in string functions.

Module 4(8 Lectures)

Functions: Concept of user-defined functions, prototype, definition of function, parameters, parameter passing, calling a function. Introduction to OOP: Basic properties, Classes and Objects, Member functions and variables, Abstract data types (ADT), Encapsulation.

Module 5 (8 Lectures)

Inheritance and Access Control: Member access control in classes, Friend functions and classes, Public Private, and Protected Inheritance, Single – Multiple – Multilevel – Hierarchical – Hybrid inheritance. Polymorphism: Runtime and compile time polymorphism.

References/Text Books

1. Samanta D.: Classic Data Structures, 2e, Prentice Hall India, 2009.
2. Richard F. Gilberg, Behrouz A. Forouzan: Data Structures: A Pseudocode Approach with C, 2e, Cengage Learning, 2005.
3. Aho A. V., J. E. Hopcroft, J. D. Ullman: Data Structures and Algorithms, Pearson Publication, 1983.
4. Tremblay J. P., P. G. Sorenson: Introduction to Data Structures with Applications, 2e, Tata McGraw Hill, 1995.
5. Horwitz E., S. Sahni, S. Anderson: Fundamentals of Data Structures in C, University Press (India), 2008.

| Semester 3 | | | | | | |
|--|---|------------|------------------|------|---|--------|
| 24-813-0302 | Computer Fundamentals 2 (Course Level 200-299) | TYPE | L | T | P | CREDIT |
| | | MIN | 4 | 1 | 0 | 4 |
| Course Outcomes (CO) | | | Revised BT Level | | | |
| <i>After the completion of the course, the students will be able to:</i> | | | | | | |
| CO1 | Understanding basic concepts of Number systems and digital logic | Understand | | | | |
| CO2 | Understand the basic concepts of Computer organization and architecture | Understand | | | | |
| CO3 | Understand the basic working principles of operating system and its process | Understand | | | | |
| CO – PSO Mapping | | | | | | |
| CO | PSO1 | PSO2 | PSO3 | PSO4 | | |
| CO1 | 2 | - | - | - | | |
| CO2 | 2 | - | - | - | | |
| CO3 | 2 | - | - | - | | |
| : Correlations Levels: 1 = Low, 2 = Medium, 3 = High, “-” = No correlation | | | | | | |
| Syllabus | | | | | | |
| Module 1(8 Lectures) | | | | | | |

Number Systems and Codes: Binary Number system – Binary to decimal – decimal to binary – hexadecimal – ASCII code Digital Logic: The Basic Gates – NOT, OR, AND - Universal Logic Gates – NOR, NAND. Boolean Laws and Theorems.

Module-2(10 Lectures)

Basic Computer Organization and Design: Instruction codes - stored program organization - Computer registers and common bus system - Computer instructions - Timing and control - Instruction cycle: Fetch and Decode - Register reference instructions.

Module-3 (8 Lectures)

Central Processing Unit: General register organization - stack organization – instruction formats - addressing modes - Input-output organization: Peripheral devices - I/O interface - Memory organization: Memory hierarchy - Main memory - Auxiliary memory

Module-4(8 Lectures)

Overview of Operating Systems, Types of OS, OS Operations, Resource Management, Kernel Processes- Process concept, forks and pipes, Interrupt processing, Process Scheduling, CPU Scheduling Algorithms

Module-5 (6 Lectures)

Process Synchronization- Critical Section Problem, Mutex Locks, Semaphores, Deadlocks- Methods of Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance

References/Text Books

1. Digital Principles and Applications – Donald P Leach, Albert Paul Malvino, GoutamSaha, 8th edition, McGraw-Hill Education, 3rd reprint 2015. R. P. Jain, “Modern Digital Electronic”, McGraw-Hill Publication, 4th Edition.
2. William Stalling, “Computer Organization and Architecture: Designing and Performance”, Pearson Publication 10TH Edition.
3. Computer System Architecture, M. Morris Mano, Pearson Education, 3rd edition.,2007
4. Operating System Principles, Abraham Silberchatz, Peter B. Galvin, Greg Gagne,10th Edition, Wiley Student Edition. 2018
5. Operating System-Internals and Design Principles, W.Stallings, 6th Edition, Pearson.
6. Strang, Gilbert. Modern Operating System, Andrew s Tanenbaum, 3rd Edition, PHI