Academic Programme offered by

Department of Information

Technology IIIT Lucknow

M. Sc.
Artificial Intelligence and Machine Learning

Eligibility for Admission:

Students completed B.A./BCA/B.S./B.Sc./B.Stat. /B.Math./ B.Tech/B.E. or any other equivalent degree with IT/ CS/ Mechanical/Electronics/ Electrical/ Mathematics/ Statistics or any other related field as major are eligible to apply. Selection for the programme will be through Joint Admission Test for Masters (JAM). Atleast one subject of Computer programming Language- C/C++/JAVA/Python should have been passed with minimum 60% marks or completed a certificate course in any of the programming languages. Students should have working knowledge of coding in any one programming language mentioned above. For further information related to admission test, syllabus, cutoff etc. will be available on the JAM website.

How to Apply:

Selection for the programme will be through Joint Admission Test for Masters (JAM). Counseling will be conducted by CCMN.

Outcome of the Program

IIIT Lucknow introduces M.Sc. in AI & ML with the focus of catering young minds with the idea of applying Artificial Intelligence and Machine learning in areas like NLP, Optimization, Data mining. The focus of this course is to make the students industry ready. The course has been designed in a such a way that students having basic background in mathematics at the entry level can fruitfully participate in this program. After completing each semester students can take up various capstone projects based on their learning.

M. Sc. Artificial Intelligence & Machine Learning

Course Structure 2024

(Minimum 80 credits to be completed)

Semester I	Semester II	Semester III	Semester IV
Computational Thinking through Programming* (4 Credits)	Deep Learning* (4 Credits)	Natural Language Processing * (4 Credits)	Thesis/Industry Project (20 Credits)
AI & ML with Python* (4 Credits)	MLOps (4 Credits)	Reinforcement Learning* (4 Credits)	
Mathematical methods for Data Science and AI & ML (4 Credits)	Database Management System (4 Credits)	Elective-I (4 credits)	
Probability and Statistics with Python (4 Credits)	Image and Vision Processing* (4 Credits)	Elective-II (4 credits)	
Professional Communication (3 Credits)	Data Structures and Algorithms with Python (4 Credits)	Capstone Project (4 Credits)	
Yoga and Fitness (1 Credit)			
(20 Credits)	(20 Credits)	(20 Credits)	(20 Credits)

* Indicates the scope of a learning based Project.

List of Electives

- Information Retrieval
- Data mining & warehousing
- AI for IoT
- Data Security
- Mobile Application Development using AI/ML
- Distributed AI
- AI Blockchain
- Distributed Systems
- Soft Computing
- Software Engineering
- Optimization Techniques
- Tensorflow

Seat Matrix

Open	Open-PwD	EWS	EWS-PwD	SC	ST	OBC-NCL	Total
11	1	3	0	5	2	8	30

Fee Structure

Semester-wise	I	II	III	IV
Total Fees	Rs.72000	Rs.51500	Rs.53500	Rs. 51500

*** Hostel and Mess charges will be separate.**

NEP 2020 Implementation for M.Sc. 2023 Batch Onwards

• **Multiple Entry Multiple Exit**

According to 11.5 of NEP 2020 (pp 37), we have implemented multiple entry and exit point for our M.Sc. 2023 batch onwards in the following manner:

- Any student can leave the course after FIRST Year of M.Sc.; such students will be granted PGD in AI & ML.

- Cooling Period: The student who wants to leave his/her study after FIRST year can leave, however to complete the M.Sc. Degree, (s)he has to come back and join the course directly in SECOND year within the BLOCK period of two years. (S)He will get at most four years to complete M.Sc. degree.

• **Multidisciplinary Education :** According to 11.7 of NEP 2020 (pp 37), A course in Professional Communication and Sports have been included in the course structure.

• **Multi-Mode and Digital Education:** According to the Point 24 of NEP 2020 (pp 58),

- The subjects which are running in online mode, will be evaluated through proctored online examination

Course Syllabus

FIRST SEMESTER

Course Code: CTP1301C **Semester:** I

Course Name: Computational Thinking through Programming

Credits	L	T	P	Section (Group)
4	3	0	1	M.Sc.

Course Module Details

Objective(s)	The objective of this course is to grow the computational thinking and prob- lem solving ability of students. Moreover, the aim of this subject is to create various programming concepts such as inputs/outputs, variables, control statements, functions, arrays, pointers, structures, etc. For coding or writ- ing the programs, syntaxes of C language will be taught.
Description	• **Introduction to Digital Computer and Programming(2 hours):** Basic components of computer, binary representation, bits and bytes, program, software. • **Introduction to Computational Thinking (2 hours):** Procedu- ral computational approach to real life problems, idea of algorithms, creating flowcharts and pseudo-code. • **Introduction to Computational Problem Solving through C (2 hours):**Programming language concepts and its applicability on prob- lem solving, introducing C programming language, inputs and outputs, compiling and running C program • **C Fundamentals (4 hours):** C character set, identifiers and key- words, data type, consonants, declarations, operators (arithmetic, re- lational, logical, assignment, unary, bitwise, etc.). • **Control Statements (4 hours):** Branching: if-else, Looping: while, do-while, for, nested control, switch, break, continue, goto. • **Functions (4 hours):** Defining a function, accessing a function, func- tion prototypes, argument passing, recursion. • **Variables (3 hours):** variable and their scopes, automatic, exter- nal/global, static variables. • **Arrays (4 hours):** Defining an array, processing arrays, passing ar- rays to functions, multi-dimensional arrays. • **Structure and Unions (3 hours):** Defining and processing a struc- ture, user defined data types, structures and pointers, passing structure to functions, self-referential structures, Unions.

Description	• **Data Files (3 hours):** File handling, multi-file programming. • **String (2 hours):** Defining and processing string. Various operations on string. • **Program analysis (1 hour):** Debugging programs with gdb, memory analysis using valgrind. • **Capstone Project (2 hours):** A capstone project using majority of the above modules.
Pre-Requisites	No prior programming experience is assumed. However, logical and rational maturity at the level of a first year engineering or science undergraduate is assumed.
Laboratory Experiments:	Implementation of all the above modules covered in theory through C programming.
Learning Outcomes Expected:	After completing the course, the student will be able to:. • Computationally think and analyze a real-life problem. • Write pseudo codes and corresponding program in C for a undertaken project. • Comprehend the logic and procedural flow of a program. • Acquire knowledge various syntaxes and concepts of C programming. • Undertake some advanced courses, e.g., Algorithms, Advanced Programming Languages, etc.

Contact Details: Dr. Chandranath Adak, Department of Computer Science, IIITL, chandra@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Byron Gottfried, *Schaum's Outline: of Programming with C*, 4th Edition, McGraw-Hill, 2018.
2. E. Balaguruswamy, *Programming in ANSI C*, 8th Edition, Tata McGraw-Hill, 2019.

- **References**

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Second Edition, Prentice Hall of India, 1988.
2. Herbert Schildt, *C: The Complete Reference*, 4th Edition, McGraw Hill Education, 2017.

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Department of Computer Science

Semester: I

Course Code:
M M D S 1 3 1 0

Course Name: Mathematical Methods for Data Science & AI ML

Credits	L	T	P	Section (Group)
4	3	0	1	M.Sc.

Course Module Details

Objective(s)	Introduce basic mathematical concepts related to data science, machine learning and artificial intelligence.
Pre-Requisites	Basic knowledge of any programming language would be useful.
Description	• **Vectors and Matrices (10 hours): Vectors in data science, machine learning and artificial intelligence, Basics of Matrix Algebra,Vector Space, Subspace, Basis and Dimension. Linear Transformations, Norms and Spaces, Orthogonal Complement and Projection Mapping, Eigenvalues and Eigenvectors, Special Matrices and Properties.** • **Matrix Decomposition and Its Applications (10 hours): Spectral Decomposition, Singular Value Decomposition, Low Rank Approximations, Principal Component Analysis, Linear Discriminant Analysis, Applications of Low-rank Approximation, SVD, PCA, LDA.** • **Calculus and Least Square Approximation(10 hours): Basics concepts of Calculus, gradient, Jacobian, Chain rule, Change of variables. Least Square Approximation and Minimum Norm Solution, Linear and Multiple Regression, Logistic Regression. Classification Metrics, Gram Schmidt Process, Polar Decomposition, Minimal Polynomial and Jordan Canonical Form, Some more Matrices, Applications of these concepts in Data Science, Machine Learning and Artificial Intelligence.** • **Optimization (10 hours): Convex sets and convex functions, prop-erties of convex functions, Introduction to Optimization, Numerical Optimization in Machine Learning, Gradient Descent and other optimization algorithms in machine learning, Introduction to SVM, Error minimizing LPP, Lagrangian Multiplier method, concepts of duality, hard and soft margin classifier, Applications of Optimization, SVM.**

Learning Outcomes Expected:	• Describe the problem of data science/machine learning/artificial intelligence from the point of view of function approximation, optimisation, linear algebra, and statistics. • Identify the most suitable approach for a given data science/machine learning/artificial intelligence problem. • Analyse the performance of various data science/machine learning/artificial intelligence algorithms from the point of view of computational complexity and statistical accuracy.

Contact Details: Dr. Mary Samuel, Department of Mathematics, IIITL, marysamuel@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. W. Cheney, Analysis for Applied Mathematics. New York: Springer Science Business Medias, 2001.

2. S. Axler, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.

3. J. Nocedal and S. J. Wright, Numerical Optimization. New York: Springer Science Business Media, 2006.

- **References**

1. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*, Second Edition, Prentice Hall of India, 1988.

Department of Mathematics

Semester: I

Course Code: PSC3300C

Course Name: Probability and Statistics with Python

Credits	L	T	P	Section (Group)
4	3	1	0	M.Sc.

Course Module Details

**** SYLLABUS SAME AS IN M.SC(DS)**

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Department of Management and Humanities

Semester: I

Course Code: PCO2300C

Course Name: Professional Communication

Credits	L	T	P	Section (Group)
3	3	0	0	M.Sc.

Course Module Details

Objective(s)	The objective of the course is to build a toolkit of communication skills that will enable students to become an effective communicator. It aims at advancing the soft-skills in students to increase their employability prospects. It prepares them for dealing with stressful situations in their professional career.
Description	• **Basics of Communication (2 hours):** Overview of Communica- tion, Types of Communication, 7 Cs of Communication, Barriers to Communication, Need for Professional Communication, Role of Professional Communication in Industries, Job Opportunities in Professional Communication • **Conversation (6 hours):** Creating a Communication Strategy, Introducing Yourself, Networking, Conversation and Dialogues: Starting a Conversation, Ending a Conversation, Telephonic Conversation, How to Handle Difficult Conversations, What to Say and What Not to Say in Crisis Situation • **Non-Verbal communication (8 hours):** Body Language: Facial Expressions, Posture, Eye Contact, Kinesics, Proxemics, Chronemics, Haptics, Cross-Cultural Communication, Voice Features: Tone, Voice Modulation, Fluency, Rate of Speech, Pitch • **Effective Speaking (22 hours):** How to Cope with Public Speaking Anxiety, Presentation Skills: Planning, Composition, Review, Oral Presentation, Online Presentation, Interview, Group Communication- Introducing Others, Giving Feedback, Delivering Bad News, Group Discussions. • **Communicating with People in Stress (4 hours):** Awareness about Psychological Impact of Stress, What People Experience in a High-Stress Environment, Positive Communication: Practicing Empa- thy, A Good Listener, Reassurance, Follow Up.
Pre-Requisites	Basic Proficiency in English Language

Learning Outcomes Expected:	After completing the course, the student will be able to:. • effectively use soft skills in professional settings • employ communication strategies in situations of crisis • plan and make effective oral presentations with/ without visual aid • communicate effectively in high-stress environment

Contact Details: Dr. Neelu, Department of Management & Humanities, neelu@iiitl.ac.in

Courseware and Reference Books

1. Text Books

a. Raman, M., & Sharma, S. , *Technical communication: Principles and practice*, Oxford University Press, 2015.

2. References

a. Anderson, P. V, *Communicative English for engineers and professionals*, Pearson Education India, 2010.

b. Mishra, S., & Muralikrishna, C. , *Communication Skills for Engineers*, Pearson Education India, 2011

c. Nitin, B. , *Communicative English for engineers and professionals*, Pearson Education India, 2010

d. Farrell, A., & Geist-Martin, P. , *Communicating social health: Perceptions of wellness at work*, Man- agement Communication Quarterly, 18(4), 543-592, 2005

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Department of Mathematics

Semester: I

Course Code:

Course Name: Mathematical Methods for Data Science and AI / ML

Credits	L	T	P	Section (Group)
4	3	1	0	M.Sc.

Course Module Details

**** SYLLABUS SAME AS IN M.SC(DS)**

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Department of Computer Science

Semester: I

Course Code:

Course Name: AI/ML with Python

Credits	L	T	P	Section (Group)
4	3	0	1	M.Sc. (Data Science and AI & ML)

Course Module Details

Objective(s)

This course provides an introduction to Artificial Intelligence (AI) and Machine Learning (ML) with a focus on their theoretical foundations, algorithms, and practical applications. The course will cover key AI topics such as search strategies, as well as core ML techniques including supervised, unsupervised, and reinforcement learning. Students will gain hands-on experience with Python libraries to build AI and ML models. The course also explores ethical considerations in AI and its real-world applications.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand the fundamental concepts of AI and ML.
- Apply machine learning algorithms to real-world data and evaluate their performance.
- Build neural networks and deep learning models using Python.
- Implement AI search algorithms and optimization techniques.
- Understand the ethical implications and limitations of AI systems.
- Develop end-to-end AI and ML solutions using Python libraries and frameworks.

Pre-Requisites:

Probability, Linear Algebra, Basic Python Programming

Course Module Details

Module-1: Introduction to Artificial Intelligence and Machine Learning
History of AI, Overview of ML, AI vs ML, Applications, Search Strategies in AI, AI Applications: Robotics, Autonomous Systems: AI in Healthcare, Autonomous Vehicles, Robotics, AI Ethics and Interpretability: Bias in AI, Explainable AI, Fairness in ML.

Module-2: Data Pre-processing and Evaluation Techniques:
Data cleaning: redundancy and noise removal methods, performance evaluation parameters, confusion Matrix, over fitting, hold-out method, repeated hold-out method, k-fold Cross-Validation etc., Feature Selection and Extraction Models, Dimensionality reduction technique: Principal Component Analysis.

Module-3: Supervised approaches:
Regression Techniques: Linear regression, multiple regressions, polynomial regression and Logistic regression, Classification techniques: K-Nearest Neighbour, Decision Tree, Support Vector Machine,

Naive Bayes Classification

Module 4: Unsupervised Approaches:
Clustering techniques: K- mean clustering, K-Medoids clustering, Fuzzy C mean clustering, hierarchical and density-based clustering, clustering analysis and clustering validation.

Module 5: Ensemble Models:
Bagging and Boosting, Multi-label Classification, Reinforcement Learning and Semi-supervised classification.

Laboratory Experiments:
• Students will implement various searching and machine learning techniques and apply multiple evaluation techniques to evaluate the learning models.

Contact Details: Dr. Sushil Kumar Tiwari, Department of Information Technology, IIIT Lucknow, Email: stiwari@iiitl.ac.in.

Textbooks and References

⚜ **Primary Textbooks:**

- Russell, S., and Norvig, P., Artificial Intelligence: A Modern Approach, Pearson.
- Géron, A., Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly.

⚜ **References:**

- Bishop, C. M., Pattern Recognition and Machine Learning, Springer.
- Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, MIT Press.
- Sutton, R., and Barto, A., Reinforcement Learning: An Introduction, MIT Press.

SECOND SEMESTER

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Department of Computer Science

Semester: II

Course Code: DLE6301C

Course Name: Deep Learning

Credits	L	T	P	Section (Group)
4	3	0	1	M.Sc.

Course Module Details

Objective(s)	The objective of this course is to grow the knowledge on recent trends of advanced machine learning techniques..
Description	• **Deep Neural Network (11 hours):** Introduction to Deep Learning: A brief overview of supervised, unsupervised, reinforcement learning, Difference between classification, regression, Traditional classifiers, Multilayer Perceptron: Feed-Forward Neural Network with Backpropagation, Different activation functions their advantages and disadvantages: Sigmoid (vanishing gradient problem), ReLU (exploding gradient problem), Leaky ReLU, tanh, etc., Various loss and cost functions: MSE, log-loss, cross-entropy, hinge loss, etc., Bias vs Variance trade-off, Regularization: L2 regularization, early stopping, data augmentation, Ensembling, Dropout, etc., Optimization: Gradient Descent (GD), Batch GD, Stochastic GD, Minibatch GD, GD with momentum, Adagrad, RMSprop, Adam, etc. • **Convolutional Neural Network (7 hours):** Introduction to Convolution Neural Network (CNN), Different operations of CNN (convolution, pooling), Different concepts of CNN (Kernel, Filter, Padding, Stride), Different CNN architecture (LeNet, AlexNet, VGG Net, GoogLeNet, SqueezeNet, Xception net, Residual block and ResNet, Dense Net, etc.), Transfer Learning, Similarity learning, Siamese Net, Triplet Net

	• **Advanced Topics on Deep Learning (7 hours):** Autoencoder: Denoising autoencoder, Sparse autoencoder, Variational autoencoders, etc., Generative Adversarial Network (GAN) and some of its variants, e.g., DCGAN, CycleGAN • **Applications of Deep Learning (8 hours):** Application of Deep Learning (DL) in Computer Vision: Object Segmentation: U-Net, V-Net, Object Detection: RCNN, YOLO, etc., Application of DL in Natural Language Processing (NLP): e.g., Sentiment Analysis from reviews
Pre-Requisites	Machine Learning, Some basic knowledge of Linear Algebra and Calculus.
Learning Outcomes Expected:	After completing the course, the student will be able to • Tackle real-life computation problems that can be addressed through deep learning, • Understand various concepts of deep learning, • Solve various computer vision and natural language processing problems, • Demonstrate an understanding of some ethical issues related to artificial intelligence.

Contact Details: Dr. Chandranath Adak, Department of Computer Science, IIITL, chandra@iiitl.ac.in

Courseware and Reference Books

3. References

a. I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, MIT Press, 2016. Online: https://www.deeplearningbook.org.

b. A. Zhang, Z. C. Lipton, M. Li, A. J. Smola, *Dive into Deep Learning*, arXiv:2106.11342, 2021. Online: https://d2l.ai.

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Department of Information Tech.

Semester: II

Course Code: DSA2310C

Course Name: Data Structures and Algorithms in Python

Credits	L	T	P	Section (Group)
4	3	0	1	M.Sc.

Details

Objective(s)	• This course aims to provide students with a strong foundation in data structures and algorithms (DSA) using Python. It focuses on understanding, implementing, and analyzing various data structures and algorithms to develop efficient and optimized solutions for computational problems. • Formulate new/improved solutions for programming problems using learned data structure and apply to solve real problems using efficient design technique.

Description	
	Introduction to Data Structures and Algorithms Overview of DSA and its importance in problem-solving, Time and Space Complexity Analysis, Asymptotic Notations (O, Omega, Theta notations), order of growth. Basic sorting, searching algorithms. **Fundamental Data structures & algorithmic techniques** Introduction to Array, Array representation, Contiguous storage. Definition, operations, advantages, and limitations Divide and conquer Technique- Implementing Arrays in applications e.g., MergeSort, Quicksort, Binary Search. Recurrences and their solution- Master's theorem, Iteration, Recursion Tree Stacks, operations , Applications- expression evaluation Infix, postfix, prefix, towers of Hanoi Queue operations-Circular, Double ended, Priority Linked Lists: Singly, Doubly,Circular linked lists, and their applications in Queue, Stack Dynamic Programming and analysis: Memoization using 2-D arrays, 0/1 KSP, LCS, MCM **Advanced Data structures & algorithmic techniques** Trees: Binary Trees, Binary Search Trees (BST), AVL Trees, Heaps: Min-Heap and Max Heap, Heapsort algorithm Graphs: Representation-Adjacency Matrix, BFS and DFS traversal Backtracking and analysis: N-Queens Problem Branch and Bound : TSP, 0/1 KSP Greedy Algorithms and analysis: Coin Selection, MCST Algorithms, F-KSP, TSP, Shortest path algorithm Hashing (Search efficiency in lists and skip lists, hashing as a search structure, hash table, collision avoidance, linear open addressing, chains). **Computational complexity** P, NP, NP-C, NP-H classes and example problems-SAT, Clique problem

Pre-Requisites	Basic programming knowledge in Python, understanding of fundamental mathematics, and familiarity with basic problem-solving techniques.
Learning Outcomes Expected:	After completing the course, the student will be able to: • Analyze and compare the efficiency of different algorithms. • Implement core data structures such as arrays, linked lists, stacks, queues, trees, and graphs. • Apply sorting, searching, recursion, dynamic programming, and greedy techniques to problem-solving. • Develop optimized solutions for computational and real-world problems.

Contact Details:
Dr.

Deepshikha Agarwal, Department of Information Technology, IIITL, deepshikha@iiitl.ac.in

Courseware and Reference Books

Text Books

c. "Fundamentals of Data Structures in C" by Horowitz, Sahni and Anderson-Freed.
d. "Data Structures & Algorithms made easy: DS and algorithmic puzzles" by Narsimha Karumanchi.
e. "Introduction to Algorithms", T.H.Cormen
f. "Algorithm", by Robert Sedgewick, Kevin Wayne

4. References

a. "Data Structures and Algorithm Analysis in JAVA" by Mark Allen Weiss, 3rd Edition, (2011).
b. Algorithms" by V. Aho, J. E. Hopcroft, and J. D. Ullman, 1st edition, (1983).
c. "Grokkings Algorithms" by Aditya Bhargava.
d. "Hands-On DS and algorithms with Python", by Dr.Basant Agarwal, <packt>

List of Practicals:

- The lab programs will be solve by using Python/C++ Programming Language. For all the practicals, students will have to present the complexity analysis in best, worst and average cases

1. Implementation of binary search method in Divide and Conquer Approach
2. Implementation of Recursive Quicksort method using Array in Divide and conquer approach
3. Conversion of Infix operation to Postfix operation in Stack using Linked List and Arrays
4. Implementation of Queue in BFS traversal for TSP problem in Branch-Bound method
5. Implementation of DFS using Stack for n-Queen's problem in Backtracking method
6. Implementation of Travelling salesman problem using MCST Graph algorithms in Greedy approach
7. Implementation of Fractional Knapsack problem using Greedy approach
8. Implementation of 0/1 Knapsack problem using Dynamic approach
9. Implementation of MCM using Dynamic approach
10. Implementation of n-Queen's problem using Backtracking approach
11. Implementation of Hashing with Linear Probing

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Department of CS/IT/CS-AI/CSB

Semester: I

Course Code: DMS1301C

Course Name: Database Management System

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT, CS, CS-AI, & CSB)

Course Module Details

Objective(s)

The objective of this course is to develop the understanding of the fundamentals of relational database systems. This course will help students to learn how to construct databases using DBMS products, such as MySQL/Oracle/My SQL Server. Design database systems and understand new developments and trends in databases.

Pre-Requisites: No prior programming experience is assumed. However, logical and rational maturity at the level of a first year engineering or science undergraduate is assumed.

Description

- **Introduction (6 Hours):** Data, data processing requirement, desirable characteristics of an ideal data processing system, traditional file based system, its drawback, concept of data dependency, Definition of database, database management system, 3-schema architecture, database terminology, benefits of DBMS.
- **Relational Database (6 Hours):** Relational data model: Introduction to relational database theory: definition of relation, keys, relational model integrity rules.
- **Database Analysis (8 Hours):** Conceptual data modeling using E-R data model -entities, at- tributes, relationships, generalization, specialization, specifying constraints, Conversion of ER Models to Tables, Practical problems based on E-R data model.

- **Relational Database Design (7 Hours):** Normalization- 1NF, 2NF, 3NF, BCNF, 4NF and 5NF. Concept of Denormalization and practical problems based on these forms.
- **Transaction Management and Concurrency control (7 Hours):** Concept of Transaction, States of Transaction and its properties, Need of Concurrency control, concept of Lock, Two phase locking protocol.
- **Recovery Management (6 Hours):** Need of Recovery Management, Concept of Stable Storage, Log Based Recovery Mechanism, Checkpoint.

Laboratory Experiments:

Students will perform SQL commands to demonstrate the usage of DDL and DML, joining of tables, grouping of data and will implement PL/SQL constructs.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Analyze the Information Systems as socio-technical systems, its need and advantages as compared to traditional file-based systems.
- Analyze and design database using ER data model by identifying entities, attributes and relationships.
- Apply and create Relational Database Design process with Normalization and Denormalization of data.
- Comprehend the concepts of transaction management, concurrence control and recovery management.
- Demonstrate use of SQL and PL/SQL to implementation database applications.

Contact Details: Dr. Rahul Kumar Verma, Department of Computer Science, IIITL, rahul@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Silverschatz A., Korth F. H. and Sudarshan S., *Database System Concepts*, 6th Edition, Tata McGraw-Hill, 2010.
2. Elmasri R. and Navathe B. S., *Fundamentals of Database Systems*, 7th Edition, Pearson, 2016.

- **References**

1. Bayross I., *SQL, PL/SQL the Programming Language of Oracle*, 4th Edition, BPB Publications, 2009.
2. HofferJ., Venkataraman, R. and Topi, H., *Modern Database Management*, 12th Edition, Pearson, 2016.

Course Code: IVP6301E **Semester:** VI/Elective

Course Name: Image and Vision Processing

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s) To learn the Digital image representation, prepossessing of images (filtering in time and frequency domain), image feature extraction and analysis

Pre-Requisites Probability, Complex Numbers, Data Communication

Description

- **Introduction (8 Hours):** Elements of Visual Perception, Structure of the Human Eye, Image Formation in the Eye, Brightness Adaptation and Discrimination, Light and the Electromagnetic Spectrum, Image Sensing and Acquisition, Image Acquisition, Image Sampling and Quantization, Spatial and Intensity Resolution, Image Interpolation, Some Basic Relationships between Pixels, An Introduction to the Mathematical Tools Used in Digital Image, Linear versus Nonlinear Operations, Arithmetic Operations.
- **Image Transforms (6 Hours):** Probabilistic Methods, The Basics of Intensity Transformations and Spatial Filtering, Some Basic Intensity Transformation Functions, Image Negatives, Log Transformations, Power-Law (Gamma) Transformations, Piecewise-Linear Transformation Functions, Histogram Processing, Histogram Equalization, Histogram Matching (Specification), Local Histogram Processing, Using Histogram Statistics for Image Enhancement.
- **Spatial Filtering (6 Hours):** Fundamentals of Spatial Filtering, The Mechanics of Spatial Fil- tering, Spatial Correlation and Convolution, Vector Representation of Linear Filtering, Generating Spatial Filter Masks, Smoothing Spatial Filters, Smoothing Linear Filters, Order-Statistic (Nonlin- ear) Filters, Sharpening Spatial Filters, Second Derivative for Image Sharpening, The Laplacian, Unsharp Masking and High boost Filtering, Using First-Order Derivatives for (Nonlinear) Image, Sharpening.
- **Frequency Domain Filtering (12 Hours):** Complex Numbers, Fourier Series, Impulses and Their Sifting Property, The Fourier Transform of Functions of One Continuous, Convolution, Sampling and the Fourier Transform of Sampled Functions, The Sampling Theorem, Aliasing, Function Reconstruc- tion (Recovery) from Sampled Data, The Discrete Fourier Transform (DFT) of One Variable, The 2-D Impulse and Its Sifting Property, 2-D Sampling Theorem, Aliasing in Images, Some Properties of the 2-D Discrete Fourier Transform, Fourier Spectrum and Phase Angle, The 2-D Convolution Theorem, Correspondence Between Filtering in the Spatial and Frequency, Ideal Lowpass Filters, Butterworth Lowpass Filters, Gaussian Lowpass Filters, Image Sharpening Using Frequency Do- main Filters, Ideal Highpass Filters, Butterworth Highpass Filters, Gaussian Highpass Filters, The Laplacian in the Frequency Domain, Unsharp Masking, Highboost Filtering, and High-Frequency- Emphasis Filtering, Homomorphic Filtering, Selective Filtering, Bandreject and Bandpass Filters, Notch Filters.
- **Morphology (5 Hours):** Erosion and Dilation, Duality, Opening and Closing, The Hit-or-Miss

Transformation, Some Basic Morphological Algorithms, Boundary Extraction, Hole Filling, Extrac- tion of Connected Components, Convex Hull, Thinning, Thickening, Skeletons, Pruning

- **Image Segmentation (5 Hours):** Background Detection of Isolated Points, Line Detection, Edge Models, Basic Edge Detection, More Advanced Techniques for Edge Detection, Edge Linking and Boundary Detection, Thresholding, Foundation Basic Global Thresholding, Optimum Global Thresh- olding Using Otsu's Method, Using Image Smoothing to Improve Global Thresholding, Using Edges to Improve Global Thresholding, Multiple Thresholds, Variable Thresholding, Multivariable Thresh- olding.

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Understand concepts required for image enhancement.
- Implement image preprocessing algorithms, Feature Extraction algorithms.
- Understand and implement spatial and frequency domain filtering for image enhancement.
- Concepts learnt in this course will help understand the advance concepts of computer vision.

Contact Details: Dr. Soumendu Chakraborty, Department of CS, IIITL, soumendu@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. Rafael C. Gonzalez, and Richard E. Woods *Digital Image Processing*, Fourth Edition, Pearson.

- **References**

1. Bernd Jähne, *Digital Image Processing*, Sixth Edition, Sringer

THIRD SEMESTER

Department of Computer Science

Semester: III/IV

Course Code: NLP7301E

Course Name: Natural Language Processing

Credits	L	T	P	Section (Group)
4	3	1	0	M.Sc.

Course Module Details

Objective(s)

The general approach in the course will be covering (i) a language phenomenon, (ii) the corresponding language processing task, and (iii) techniques based on deep learning, classical machine learning and knowledge base(s). On one hand we will understand the language processing task in detail using linguistics, cognitive science, utility *etc.*, on the other hand we will delve deep into techniques for solving the problem. In addition to the graded labs, non-graded labs, and course project (graded), this course entails a *mid-semester* and an *end-semester* examination.

Pre-Requisites: Machine Learning, Linear Algebra, Calculus, and basics of Python programming.

Description

- **Week 01** (3 hours) - Introduction to Natural Language Processing (NLP)
  Course Introduction & Motivation, Multilingualism, Morphology in Languages, and
  Part-of-Speech (Pos) Tagging [Introduction].
- **Week 02** (3 hours) - PoS Tagging Layer of NLP
  Mathematics of PoS tagging, Sequences in NLP, and
  NLP Lab 1 (Non-graded) - Simple Matrix Operations, NumPy, scikit-learn
- **Week 03** (3 hours) - Hidden Markov Models (HMM) in NLP
  PoS Tagging (HMM), Viterbi Decoding for Tagging and Sequences, and
  NLP Lab 2 (Non-graded) - Most Frequent POS Tagging assignment.
- **Week 04** (3 hours) - Handling Sequential Tasks
  Shallow parsing, Named Entity Recognition (NER), Introduction to Conditional Random Field (CRF), and
  Challenges due to Morphological Richness.
- **Week 05** (3 hours) - Feature Engineering
  CRF (contd.), Maximum Entropy Markov Model (MEMM),
  Feature Extraction and Engineering, and
  NLP Lab 3 (Non-graded) - NER Task for multiple languages.
- **Week 06** (3 hours) - Knowledge Bases and Ambiguity
  Ambiguity and NLP, Knowledge Bases (WordNet, FrameNet, VerbNet *etc.*),
  Word Sense Disambiguation (WSD), and
  NLP Lab 4 (Graded) - Sense Disambiguation Task

- **Week 07** (3 hours) - Applications of Neural Networks (NN) in NLP
  Cognate Detection and its applications,
  NER using NNs, Text Classification using NNs
  Transformer Architecture, and Introduction to Distributional Semantics.
- **Week 08** (3 hours) - Distributional Semantics
  word2vec, doc2vec, sent2vec, sub-words in NLP, and FastText
  NLP Lab 5 (Non-graded) - word2vec, GloVe and FastText (pre-trained models),
  Embeddings Space Visualization.
- **Week 09** (3 hours) - Language Models (LMs)
  Introduction to State-of-the-Art LMs, BERTology, BERT-based fine-tuning for
  various NLP tasks, and
  NLP Lab 6 (Graded Lab) - NER Task with LMs.
- **Week 10** (3 hours) - Machine Translation (MT)
  Introduction to Machine Translation (MT),
  Statistical MT (SMT), Neural MT (NMT),
  NLP Lab 7 (NG) - SMT, Moses, Alignment Task.
- **Week 11** (3 hours) - Sentiment Analysis (SA)
  Introduction to Sentiment Analysis (SA), Aspect Based SA, Sarcasm Detection,
  Thwarting, and Introduction to Course Project.
- **Week 12** (3 hours) - Information Extraction (IE)
  Question Answering, Summarization, Essay Grading, and
  NLP Lab 8 (Graded) - Aspect-based SA.
- **Week 13** (3 hours) - Cognitive NLP
  Cognitive Behaviour, Introduction to Eye-tracking (ET) / EEG,
  Ethics and Bias in NLP, Features from ET, NLP Tasks with ET.
- **Week 14** (1 hour) - Course Project
  One hour for discussion on project progress,
  Other two hours for evaluation of the project.

Learning Outcomes Expected:

At the end of this course, all the attending students are expected to be able to:

- Demonstrate an understanding for various NLP sub-problems,
- Design solutions for real-world NLP challenges,
- Solve NLP problems/challenges with the help of Machine Learning- and Deep Learning-based approaches,
- Demonstrate an understanding of ethical issues, and bias in Artificial Intelligence (AI)-based problems.

Contact Details:

https://dipteshkanojia.github.io Dr Diptesh Kanojia, Department of CS, IIITL, diptesh@iiitl.ac.in,
https://murthyrudra.github.io/ Dr Rudra Murthy V, Department of CS, IIITL, rudramurthy@iiitl.ac.in

Courseware and Reference Books

Note: This is not an exhaustive list of reading proposed by the course instructors. We shall add to this list as the course progresses.

- Allen, James, *Natural Language Understanding*, Second Edition, Benjamin/Cumming, 1995. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993
- Jurafsky, Dan and Martin, James, *Speech and Language Processing*, Speech and Language Processing (3rd ed. draft), Draft chapters in progress, October 16, 2019.

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Department of CS

Semester: III

Course Code:
Course Name: Reinforcement Learning

Credit	L	T	P	Section (Group)
4	3	0	1	M.Sc.

Course Module Details

Description	
	Unit 1: Overview of Machine Learning and AI, Agents, Intelligent agents, and agent types, Environment and its types, Multi-Agent System (MAS), Game Playing and Game Theory, **Unit2:** Introduction to Reinforcement Learning, Definitions and Key Concepts, Comparison between Supervised, Unsupervised, and Reinforcement Learning, Elements of Reinforcement Learning: Agents, Environments, States, Actions, Rewards, Probabilities **Unit 3:** Definition and Components of MDP, Bellman Equations, Policies: Deterministic and Stochastic, Value Functions: State Value Function (V) and Action Value Function (Q), Optimality and Solving MDPs, Elements of Probability, Dynamic programming, policy iteration, policy improvement, policy updation. **Unit 4:** Passive Learning: Key concepts, process, examples, methods: Direct Utility Estimation, Temporal Difference learning, Monte Carlo Methods, advantages, and disadvantages. Active learning: Key concepts, examples, process, methods: Q-Learning, SARSA (State-Action-Reward-State-Action), advantages and disadvantages. Model-Based Reinforcement Learning, Model-Free Reinforcement Learning. **Unit 5:** Deep Reinforcement Learning: DQN and its types, Components, Neural Networks, CNN, RNN & LSTM working & Case studies for Deep reinforcement learning and Reinforcement learning

Contact Details: Dr. Saurabh Shukla. Department of Computer Science. IIIT Lucknow
saurabh.shukla@iiitl.ac.in

Courseware and Reference Books

• References

1.“Reinforcement Learning: An Introduction”, Richard S. Sutton and Andrew G. Barto, 2nd Edition.
2.“An Introduction to Deep Reinforcement Learning”, Vincent François-Lavet, Peter Henderson, Riashat Islam, Marc G. Bellemare and Joelle Pineau.
3.“Algorithms for Reinforcement Learning”, Csaba Szepesvari
4. [For Probability Primer] - “Probability, Statistics, and Random Processes for Electrical Engineering”, 3rd Edition, Alberto Leon-Garcia.
5. [For Probability Primer] - Lecture Notes on Introduction to Probability, Dimitri P. Bertsekas and John N. Tsitsiklis,

ELECTIVES

Department of CS/IT

Semester: Elective

Course Code: OTE7301E

Course Name: Optimization Techniques

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective(s):

- To develop the understanding of the concepts related to different optimization techniques including linear, non-linear, meta-heuristic algorithms, dynamic programming, among others, and their applications to real-life problems.
- To understand the theory of when and why these techniques work.

This will provide students with a sound background in the area and benefit those who wish to pursue doctoral or master level theses in this subject, or apply these techniques to their own areas.

Pre-Requisites: Probability, Basics of Programming Language (preferable Python)

Description

- **Mathematical preliminaries (6 Hours):** Linear algebra and matrices, Vector space, Eigen anal- ysis, Elements of probability theory, Elementary multivariable calculus
- **Introduction (2 Hours):** Historical Development, Engineering applications of optimization, State- ment of an optimization problem, Classification of optimization problems
- **Linear Programming (8 Hours):** A brief review of simplex and revised simplex algorithms, Bland's rule, duality theory, large scale linear programmes, computational complexity of simplex method, polynomial time algorithms— ellipsoidal and Karmarkar's methods
- **Non-linear Programming (8 Hours):** General constrained mathematical programming prob- lems, KuhnTucker-Lagrangian necessary and sufficient conditions, interior point methods, standard algorithms like feasible direction and gradient projections convergence of the methods, convex pro- gramming problems, quadratic programming.

- **Integer Programming (6 Hours):** All integer and mixed integer programming problems, cutting planes and branch and bound algorithms, introduction to the ideas of NP-completeness, travelling salesman and other related problems
- **Single and Multi-objective Optimization (2 Hours):** Single vs. Multi-objective optimization techniques with evolutionary computing, dominance and non-dominance relationship. Case studies from real-life.
- **Nature Inspired optimization (8 Hours):** Traditional methods, Simulated Annealing, Genetic algorithms, Differential Evolution, Particle Swarm Optimization, Ant-Colony Optimization, Grey Wolf Optimization, Use-cases.

Learning Outcomes Expected:

After completing the course, the student will be able to

1. Learn efficient computational procedures to solve optimization problems.
2. Cast real-life minima/maxima problems into optimization framework
3. Identify appropriate optimization method to solve complex problems involved in real-life.

Contact Details: Dr. Naveen Saini, Department of CS, IIITL, naveen@iiitl.ac.in

Courseware and Reference Books

1. Rardin, Ronald L., *Optimization in Operations Research*, Pearson Education (2005).
2. Ravindran A, Phllips D.T. and Solberg J.J. *Operation Research: Principles and Practice*, John Wiley (2007)
3. R. Fletcher, *Practical methods of optimization*, 2nd Edition, Wiley, 2000, New York
4. E. K. P. Chong and S. Zak, *An introduction to optimization*, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore
5. D. Luenberger, *Linear and nonlinear programming*, 2nd Edition, 1984, Kluwer Academic Publisher, New York
6. Jorge Nocedal and Stephen Wright, *Numerical Optimization*. 2nd Edition. Springer, 2006
7. Deb, Kalyanmoy, *Multi-objective optimisation using evolutionary algorithms: an introduction*, 2011, Springer.

In addition to the above references, selection of papers from leading conferences and journals in optimization, as well as applied areas (see links on lecture slides) such as information theory, and machine learning can also be referred for details.

Department of IT

Semester: V

Course Code: SCO5301C

Course Name: Soft Computing

Credits	L	T	P	Section (Group)
4	3	0	1	B.Tech. (IT)

Course Module Details

Objective(s)

The course discusses soft computing techniques and their real-world applications. Course consists of fuzzy logic, its representation implementation. Detailed discussion on single and multiple objective optimization problem solving techniques are included in this course. This course also explains evolutionary algorithm and their adaptive nature to solve different optimization problems. Ant Colony Optimization, Particle Swarm Optimization, and Genetic Algorithm structure, role, and application will be covered in this course. ANN model, training and implementation with current state of the art will be covered in this course.

Pre-Requisites: Basic knowledge of MATLAB and discrete mathematics to understand the concepts of fuzzy logic.

Description

- **Module 1 (Contact hours: 15)** Introduction to soft computing: Soft Computing definition, soft computing Vs hard computing, Applications of soft computing Techniques, Introduction and Fuzzy Logic: Fuzzy set, Operation on Fuzzy set, fuzzy membership function, fuzzy proposition, fuzzy interference, Fuzzy relations, application of fuzzy logic, removal of fuzziness.
- **Module 2 (Contact hours: 15)** ANN and hybrid system: Introduction to Artificial Neural Net- work, MP Neuron Model, Perceptron Model, Sigmoid Neuron Model, Weight settings, activation function, back-propagation, Gradient Descent Optimization for ANN Training and applications of ANN.
- **Module 3 (Contact hours: 10)** Evolutionary Algorithms: Genetic Algorithm, Schema Theory, GA Operators: Encoding, Crossover, Mutation, Selection, etc., Particle Swarm Optimization, Artificial Bee Colony.

Laboratory Experiments:

Fuzzy Logic, Multi Objective Optimization, ANN Implementation on MATLAB/Pyhton

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Design fuzzy logic controller.
- Solve single or multi-objective optimization problems.
- Apply soft computing techniques to many real-world applications.

Contact Details: Dr. Rahul Kumar Verma, Department of Computer Science, IIITL, rahul@iiitl.ac.in

Courseware and Reference Books

- **Text Books**

1. S. Rajasekaran and G.A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, PHI Learnings Pvt. Ltd.
2. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley.

- **References**

1. Fakhreddine O. Karray and Clarence De Silva, *Soft Computing and Intelligent Systems Design - Theory, Tools and Applications*, Pearson.

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Department of CS/IT

Semester: Elective

Course Code:
Course Name: AI for IoT

Credits L T P Section (Group)
4 3 0 1
B.Tech. (IT/CS/CS-AI) M.Tech.(CS)

Course Module Details

Objective:
The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.
Pre-Requisites: Basics of Programming Language (preferable Python), Cloud Computing, Comupter Network and Wireless Communication
Description

• Introduction to IoT (10 Hours): Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.
• Elements of IoT (10 Hours): Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.
• IoT Applications (9 Hours): Development Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.
• AI based IoT Case studies (8 Hours): IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

Learning Outcomes Expected:
After completing the course, the student will be able to
1. Understand internet of Things and its hardware and software components
2. Understand the design aspects of hardware and software components of IoT.
3. Design Interface for Input and Output devices, sensors communication modules.
4. Analyze and process of data from sensors
5. Apply IoT knowledge to Implement basic IoT applications on embedded platform.

Contact Details: Dr. Niharika Anand , Department of IT, IIITL, niharika@iiitl.ac.in

Courseware and Reference Books
1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRCPress
2. Vijay Madisetti, Arshdeep Bahga, ¨Internet of Things, "A Hands on Approach", UniversityPress

3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, “Introduction to Internetof Things: A practical Approach”, ETILabs
4. Adrian McEwen, “Designing the Internet of Things”,Wiley

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Department of Computer Science

Course Name: Distributed System
Credits L T P 4 3 0 1
Section (Group) : B.Tech. (CS, IT), M.Tech

Course Module Details

Objective(s)
1.To understand the fundamentals and knowledge of the architectures of distributed systems.
2. To gain knowledge of working components and fault tolerance of distributed systems
3. To make students aware about security issues and protection mechanisms for distributed environments.

Pre-Requisites: Operating System , Computer Network.

Description
● Introduction of Distributed System (3 hours): Introduction, Examples, Issues, Common sub problems, Implementation, Parallel versus Distributed System.
● Architecture (3 hours): Centralized, Decentralized, Hybrid Architectures, Architectures versus Middleware, Self management in Distributed System.
● Communication (3 hours): Layered Protocol, Types of Communication, Remote Procedure Call (RPC).
● Naming (3 hours): Names, Identifiers and Address, Flat, Structured, Attribute based Naming.
● Synchronization (3 hours): Clock Synchronization, Logical Clocks, Mutual Exclusion, Global Positioning of Nodes, Election Algorithms.
● Mutual Exclusion (3 hours): Definition, Message Passing System, Token Passing Algorithms, Shared Memory Model, Mutual Exclusion using special instruction, Group Mutual Exclusion
● Distributed Snapshot (3 hours):Introduction, Properties of Consistent Snapshots, CHANDY LAMPORT, LAI-YANG Algorithm, Distributed Debugging.
● Global State Collection (3 hours): Introduction, Elementary Algorithm for all to all Broadcasting, Termination Detection Algorithm, WAVE Algorithms, Distributed Deadlock Detection.
● Fault Tolerant System (3 hours): Introduction, Classification and Specification of FAULTS, Fault Tolerant Systems, Tolerating CRASH & OMISSION Failures.
● Distributed Transactions (3 hours): Introduction, Classification, Implementing Transactions, Concurrency Control and Serializability, Atomic Commit Protocols, Recovery from Failures.
● Replicated Data Management (3 hours): Introduction, Stabilizing Spanning Tree Protocol , Stabilizing Maximal Matching, Distributed Reset, Stabilizing Clock Phase Synchronization, Architecture of Replicated Data Management, Data-Centric consistency Models, Client-Centric consistency Protocols. QUORUM based Protocols, REPLICA Placement, BREWER'S CAP Theorem, Case Studies.
● Security in Distributed Systems (3 hours):Introduction, Security Mechanisms, Common Security Attacks, Encryption, Secret key Cryptosystem, Public key Cryptosystem, Digital

Signatures, Hashing Algorithms.

Learning Outcomes Expected:

By the end of the course, students should be able to
1. Understand the principles and desired properties of distributed systems based on different application areas.
2. Understand and apply the basic theoretical concepts and algorithms of distributed systems in problem solving.
3. Recognize the inherent difficulties that arise due to the distributed-ness of computing resources.
4. Identify the challenges in developing distributed applications
Contact Details: Dr. Mainak Adhikari, Department of Computer Science, IIITL, mainak@iiitl.ac.in

Courseware and Reference Books

Text Books
1. Roberto Vitillo ,Understanding Distributed Systems.
2. George Coulouris, Jean Dollimore , Tim Kindberg , Gordon Blair, Distributed System Concepts and Design.
3. A.D. Kshemkalyani, M. Singhal, Distributed Computing,Principles, Algorithms, and Systems

References
1 Andrew S Tanenbaum , Distributed Systems : Principles and paradigms.
2 Sukumar Ghosh ,Distributed Systems: An Algorithmic Approach

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Department of CS/IT

Semester: III

Course Code:

Course Name: Data Mining and Warehousing

Credits	L	T	P	Section (Group)
4	3	0	1	

Course Module Details

Objective(s)

Upon Completion of the course, the students will be able to:
Store voluminous data for online processing, Preprocess the data for mining applications, Apply the association rules for mining the data, Design and deploy appropriate classification techniques, Cluster the high dimensional data for better organization of the data, Discover the knowledge imbibed in the high dimensional system, Evolve Multidimensional Intelligent model from typical system, Evaluate various mining techniques on complex data objects

Description

Part I: Overview: Motivation (for Data Mining),Data Mining- Definition and Functionalities, Data Processing, Form of Data Preprocessing, Data Cleaning: Missing Values, Noisy Data, (Binning,Clustering, Regression, Computer and Human inspection),Inconsistent Data, Data Integration and Transformation. Data Reduction: Data Cube Aggregation, Dimensionality reduction, Data Compression, Numerosity Reduction, Clustering, Discretization and Concept hierarchy generation.

Part II: Concept Description: Definition, Data Generalization, Analytical Characterization, Analysis of attribute relevance, Mining Class comparisons, Statistical measures in large Databases. Measuring
Central Tendency, Measuring Dispersion of Data, Graph Displays of Basic Statistical class Description, Mining Association Rules in Large Databases. Association rule mining: mining Single-Dimensional
Boolean Association rules from Transactional Databases, Apriori Algorithm, Mining Multilevel Association rules from Transaction Databases and Mining Multi-Dimensional Association rules from Relational
Databases.

Part III: Classification and Predictions: What is Classification and Prediction, Issues regarding Classification and prediction, Decision tree, Bayesian Classification, Classification by Back propagation,
Multi-layer feed-forward Neural Network, Back propagation Algorithm, classification methods K-nearest neighbour classifiers, Genetic Algorithm. Cluster Analysis: Data types in cluster analysis, Categories of clustering methods, partitioning methods. Hierarchical Clustering- CURE and Chameleon. Density Based methods-DBSCAN, OPTICS.Grid

Based Methods- STING, CLIQUE. Model Based Method Statistical Ap- proach, Neural Network approach, Outlier Analysis.

Part IV: Data Warehousing: Overview, Definition, Delivery Process, Difference between Database System and Data Warehouse, Multi Dimensional Data Model, Data Cubes,Stars, Snow flakes, Fact Constellations, Concept hierarchy, Process Architecture, 3 Tier Architecture

Part V: Data Marting. Aggregation, Historical information, Query Facility, OLAP function and Tools. OLAPServers, ROLAP, MOLAP

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Identify the most important informational and analytical needs of an enterprise, and develop a data warehouse solution that serves the purpose.
- Use the data warehouse solution to perform simple data mining tasks.
- Re-engineer the operational database(s) of a given enterprise and provide a data warehouse design focused on addressing the most important informational and analytical needs of the enterprise.
- Apply specific design techniques to address the data structuring challenges of the data warehouse development process. Use analysis and data mining tools; Assess the effectiveness and usability of data warehousing solutions.
- Apply one or more basic data mining techniques to identify frequent patterns, associations, and correlations in the data.
- Apply one or more basic data mining techniques to make categorical predictions on new incoming data.
- Create, populate with data, and extract useful information from a data warehouse.
- Address the challenges of using data warehousing in strategic decision making, calculate the costs, and name the benefits and limitations of such an approach..

Contact Details: Dr. Vishal Krishna Singh. Department of Computer Science. IIIT Lucknow, vks@iiitl.ac.in

Courseware and Reference Books

Text Books

- 1. Ralph Kimball, Margy Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, Wiley Publications, 3rd Edition, 2013.
- 2. Witten, Ian H., Frank, Eibe, Hall, and Mark A., Data Mining: Practical Machine Learning Tools and Techniques, 3rd ed. Morgan Kaufmann, 2011.
- 3. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining, First Edition,

Pearson Education, 2016.

- 4. Richard Roiger, Michael Geatz, Data Mining: A Tutorial-based Primer, Illustrated Edition, Addison Wesley, 2003.

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Department of CS/IT

Semester: V

Course Code: C L C 5 3 0 0 C

Course Name: Cloud Computing

Credits	L	T	P	Section (Group)
4	3	0	1	

Course Module Details

Objective(s)

Upon Completion of the course, the students will be able to:
Learn cloud computing solutions design and justify design decisions, state of the art cloud computing technologies and best practices, fundamental principles of distributed computing and how virtualization has enabled the development of cloud computing, architecture of cloud systems and the role of virtual machines in data canters. The students will also learn the basics of Big Data and cloud security.

Description

Part I: Introduction to Cloud Computing: Cloud Computing Fundamentals, definition and History, Key Characteristics and Benefits, Cloud Service Models, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS).

Part II: Cloud Architecture and Deployment Models: Cloud Architecture, Essential Components and Technologies, Virtualization and Containerization, Deployment Models, Public, Private, Hybrid, and Community Clouds, Comparative Analysis and Use Cases

Part III: Cloud Security and Compliance: Security in the Cloud, Threats and Vulnerabilities, Best Practices and Tools, Compliance and Governance, Regulatory Requirements, Managing Compliance in Cloud Environments

Part IV: Cloud Services and Applications: Core Cloud Services, Storage, Compute, and Networking, Managed Services and Databases, Advanced Cloud Applications, Big Data and Analytics, Machine Learning and AI Integration

Part V: Practical Implementation and Future Trends, Cloud Migration and Management, Strategies for Migration to the Cloud, Management and Monitoring Tools, Future Trends in Cloud Computing, Emerging

Technologies, Predicting the Future Landscape of Cloud Services

Contact Details: Dr. Deepak Kumar Singh. Department of Information Technology. IIIT Lucknow, dks@iiitl.ac.in

Learning Outcomes Expected:

After completing the course, the student will be able to:

- Analyse cloud programming models and apply them to solve problems
- Understanding cloud infrastructure
- Design cloud computing solutions
- Research cloud computing technologies
- Understand cloud architecture
- Deploy cloud systems
- Understanding Big Data
- Understanding cloud security

Courseware and Reference Books

Text Books

- Zaigham Mahmood, Ricardo Puttini, and Thomas Erl, Cloud Computing: Concepts, Technology & Architecture, Pearson, 2013.
- Judith Hurwitz, Robin Bloor, Marcia Kaufman, and Fern Halper, Cloud Computing For Dummies, Wiley Publishing Incorporation, 2010
- Derrick Rountree , Ileana Castrillo , The Basics of Cloud Computing: Understanding the Fundamentals of Cloud Computing in Theory and Practice, Syngress; Illustrated edition, 2013