INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School for Data Science and Artificial Intelligence

Subject Code: DAC-501   **Course Title**: Machine Learning

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PCC

Course Outlines: Machine learning techniques – Introduction to supervised learning techniques and un-supervised learning techniques, feature representation, regression, supervised learning – binary-class and multi-class classification, bias, variance, regularization, performance metrics – precision, recall, accuracy, F1 score, unsupervised learning, introduction to deep learning, recent applications of machine learning

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School for Data Science and Artificial Intelligence

Subject Code: DAC-503   **Course Title:** Essential Mathematics for AI

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PCC

Course Outlines: Basics of linear algebra - System of Linear Equations; Vector- and sub- spaces; Matrices; Eigenvalues and Eigenvectors Norms; Spéctral Decomposition; Singular value Decomposition; Low-rank Approximation; Projection; Principal Component Analysis; Differentiation of univariate functions; Partial derivatives and gradients; Gradients of vector valued functions and matrices; Backpropagation and automatic differentiation; Optimization using gradient descent; Constrained Optimization techniques; Convex optimization Algorithms; Probability and Statistics - Basic concepts of probability; Conditional probability, Bayes' theorem; Moment generating functions; Joint distribution, conditional distribution; Transformations of random variables, covariance, correlation, random sample; Statistics, sampling distributions, point estimation, MAP, MLE; Information theory – Entropy and cross-entropy, KL divergence, mutual information.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAC-505   **Course Title:** Advanced Data Structures and Algorithms

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PCC

Course Outlines: Priority queues and heaps, dictionaries, hash tables, binary search trees, Asymptotic notation, recursion, divide-and-conquer paradigm, greedy strategy, dynamic programming, complexity classes P, NP, NP-hard, NP-complete, approximation algorithms, randomized algorithms, applications of algorithms.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAC-507   **Course Title:** Programming for AI

L-T-P: 0-0-6   **Credits:** 3   **Subject Area:** PCC

Course Outlines: Python: Basics, Numpy, Pandas, and Matplotlib; Scikit-Learn and NLTK; TensorFlow and Keras; TensorFlow Lite: Deploy machine learning systems on IoT device (Arduino Platform and Raspberry Pi based devices) (C/C++, Python).

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAC-513   **Course Title:** Data Structures and Algorithms

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PCC

Course Outlines: Time and Space complexity of algorithms, asymptotic analysis, hash table, uses of hash tables, insertion, deletion and search operations in sequential and linked lists, doubly linked lists, circular lists, skip lists, applications of lists, algorithm design strategies, divide and conquer, merge sort, quick sort, greedy method dynamic programming, back-tracking, applications, DFS and BFS, spanning trees, minimum cost spanning trees, Kruskal's, Prim's algorithms; path finding and shortest path algorithms, P and NP-classes, NP-hard problems, reduction.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAC-515   **Course Title:** Programming for Data Science

L-T-P: 0-0-6   **Credits:** 3   **Subject Area:** PCC

Course Outlines: Python: Basics, Numpy, Pandas, and Matplotlib; Scikit-Learn and NLTK; TensorFlow and Keras; TensorFlow Lite: Deploy machine learning systems on mobile (Android application) (Android Studio, Kotlin/ Java).

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-514   **Course Title**: Time Series Data Analysis

L-T-P: 3-1-0   **Credits**: 4   **Subject Area**: PEC

Course Outlines: Basic Properties of time-series data: Distribution and moments, Stationarity, Autocorrelation, Heteroscedasticity, Normality. Autoregressive models and forecasting: AR, ARMA, ARIMA models. Random walk model: Non-stationarity and unit-root process, Drift and Trend models. Regression analysis with time-series data using R programming. Principal Components Analysis (PCA) analysis and Factor Analysis. Conditional Heteroscedastic Models: ARCH, GARCH, T−GARCH, BEKK−GARCH. Introduction to Vector Auto-regressive (VAR) models: Impulse Response Function (IRF), Error Correction Models, Co-integration. Introduction to deep learning models: Basics of Neural Networks types, techniques for weights, Recurrent Neural Networks (RNN) and (LSTM) for time series forecasting.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-584   **Course Title:** Product and Process Optimization

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PEC

Course Outlines: Scope of Optimization; Problem Structures; Intuitive graphical methods; Necessary and Sufficient conditions for optimality; Popular classical optimization methods for unconstrained and constrained multivariate problems; Introduction to Convex Optimization; Introduction to Linear Programming; Introduction to Evolutionary Optimization – Genetic Algorithms & Particle Swarm Optimization etc.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-585   **Course Title:** Natural Language Processing

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PEC

Course Outlines: : Introduction to NLP; Text preprocessing,; N-gram language models; Evaluation metrics, Distributional semantics; Word embeddings (Word2Vec, GloVe); Neural networks for NLP; RNNs, LSTMs, training best practices, Seq2seq models; Neural machine translation; Evaluation (BLEU), Attention mechanisms; Transformers (Vaswani et al.); Pre-trained models (BERT), Summarization (extractive, abstractive); Information retrieval ,Information extraction (RE, OpenIE), Dialogue systems, Ethics in NLP; Bias and fairness; Current trends (LLMs, instruction tuning, multilingual NLP), text visualization, text clustering, topic modelling, sentiment analysis.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-586   **Course Title:** Generative AI

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PEC

Course Outlines: Autoencoder, GAN and its variants, Variational Autoencoder, DDPM model, DDIM model, Classifier free guidance, Stable Diffusion, Control Net, LORA technique, DDIM Inversion, Score Distillation, GLIDE method, Imagen model, DALL-E and CLIP models, Transformers, Visual Language Models and recent advances, Fine grained Language Image Pretraining, Hierarchy attention for vision-text pretraining, BLIP model, BLIP-2 model using LLMs, MaMMUT model for multimodal tasks, Shikra model for Referential Dialogue, Video-LLaVA model, PG-Video-LLaVA model, Evaluating LLM Hallucinations.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-587   **Course Title:** Internet of Things

L-T-P: 3-1-0   **Credits:** 4   **Subject Area:** PEC

Course Outlines: Introduction to Internet of Things (IoT), IoT architectures and protocols, communication protocols, LAN and WAN for IoT, wired and wireless networks, IoT hardware, Sensors, Actuators, Microcontrollers, Programming IoT devices (using Arduino and Python), Data collection and analytics, Cloud computing platforms, Edge/Fog computing, Cyber physical systems, IoT privacy and security.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF SCHOOL: Mehta Family School of Data Science and Artificial Intelligence

Subject Code: DAL-588   **Course Title:** Big Data and AI for Industry

L-T-P: 3-1-0   **Credits**: 4   **Subject Area**: PEC

Course Outlines: Essential Principles of Data Science and AI; Analytical Theory and Methods (Review of Basic Statistics, Experimental Design, Supervised & Unsupervised Learning); Introduction to Big Data; Deep Learning (Theory & Applications); Algorithms for Handling Large Scale Data Mining; Big Data Applications (Advertisement, Webpage Ranking, Social Networks & Media, Recommendation System, etc.); Ethical Issues in Big Data Analytics; Business and Industry Applications (Finance, Healthcare, Agriculture, Marketing, Supply Chain, Digital Platforms, etc.).