		Major Specialization: AI and ML					
		Electronics and Telecommunication Engineering / Electronics / Electronics and Communication Sandwich and Biomedical Engineering					
		SWAYAM/NPTEL Course List					
Sr No	**Sem**	**Name of Course**	**Teaching Scheme**	**Duration**	**Instructor**	**Organizing Institute**	**Credits**
1	V	Essential Mathematics for Machine Learning	4hrs/ week	8 Weeks	Prof. Sanjeev Kumar Prof. S.K. Gupta	IITR	4
2	V	Introduction to Machine Learning	4hrs/ week	12 Weeks	Prof. Balaraman Ravindran	IITM	4
3	VI	Introduction To Soft Computing	4hrs/ week	8 weeks	Prof. Debasis Samanta	IIT KGP	4
4	VI	Computer Vision and Image Processing – Fundamentals and Applications	4hrs/ week	12 Weeks	Prof. M. K. Bhuyan	IITG	4
5	VII	Deep Learning	4hrs/ week	12 Weeks	Prof. Prabir Kumar Biswas	IIT KGP	4

Note:

1) **Minimum 8 to 12 week course is required to allot 4 credits for the course.**
2) **Structure should be uniform, across all branches.**

Syllabus

Essential Mathematics for Machine Learning

Week 1: LINEAR ALGEBRA BASICS- Vector spaces and subspaces, basis and dimensions, linear transformation, four fundamental subspaces

Week 2: MATRIX THEORY- Norms and spaces, eigenvalues and eigenvectors, Special Matrices and their properties, least squared and minimum normed solutions

Week 3: MATRIX DECOMPOSITION ALGORITHMS- SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition

Week 4: DIMENSIONS REDUCTION ALGORITHMS and JCF- Principal component analysis, linear discriminant analysis, minimal polynomial and Jordan canonical form

Week 5: CALCULUS – Basic concepts of calculus: partial derivatives, gradient, directional derivatives, jacobian, hessian, , convex sets, convex functions and its properties

Week 6: OPTIMIZATION – Unconstrained and Constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, Steepest descent method, Penalty function method

Week 7: PROBABILITY – Basic concepts of probability: conditional probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, few discrete and continuous distributions, joint distributions and covariance.

Week 8: SUPPORT VECTOR MACHINES – Introduction to SVM, Error minimizing LPP, concepts of duality, hard and soft margin classifiers

BOOKS AND REFERENCES

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.

4. J. S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.

Introduction to Machine Learning

Week 0: Probability Theory, Linear Algebra, Convex Optimization - (Recap)

Week 1: Introduction: Statistical Decision Theory - Regression, Classification, Bias Variance

Week 2: Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares

Week 3: Linear Classification, Logistic Regression, Linear Discriminant Analysis

Week 4: Perceptron, Support Vector Machines

Week5: Neural Networks - Introduction, Early Models, Perceptron Learning, Neural Networks - Backpropagation, Neural Networks - Initialization, Training & Validation, Parameter Estimation

Week 6: Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures

Week 7: Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting

Week 8: Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks

Week 9: Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation

Week 10: Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering

Week 11: Gaussian Mixture Models, Expectation Maximization

Week 12: Learning Theory, Introduction to Reinforcement Learning, Optional videos (RL framework, TD learning, Solution Methods, Applications)

BOOKS AND REFERENCES

The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman (freely available online)

Pattern Recognition and Machine Learning, by Christopher Bishop (optional)

Introduction to Soft Computing

Week 1: Introduction to Soft Computing, Introduction to Fuzzy logic, Fuzzy membership functions, Operations on Fuzzy sets

Week 2: Fuzzy relations, Fuzzy proposition, Fuzzy implications, Fuzzy inferences

Week 3: Defuzzyfication Techniques-I, Defuzzyfication Techniques-II, Fuzzy logic controller-I, Fuzzy logic controller-II

Week 4: Solving optimization problems, Concept of GA,GA Operators: Encoding, GA Operators: Selection-I

Week5: GA Operators: Selection-II, GA Operators: Crossover-I,GA Operators: Crossover-II,GA Operators: Mutation

Week 6: Introduction to EC-I, Introduction to EC-II,MOEA Approaches: Non-Pareto, MOEA Approaches: Pareto-I

Week 7: MOEA Approaches: Pareto-II, Introduction to ANN,ANN Architecture

Week 8: ANN Training-I,ANN Training-II,ANN Training-III, Applications of ANN

Deep Learning

Week 1: Introduction to Deep Learning, Bayesian Learning, Decision Surfaces

Week 2: Linear Classifiers, Linear Machines with Hinge Loss

Week 3: Optimization Techniques, Gradient Descent, Batch Optimization

Week 4: Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning

Week 5: Unsupervised Learning with Deep Network, Autoencoders

Week 6: Convolutional Neural Network, Building blocks of CNN, Transfer Learning

Week 7: Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam

Week 8: Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization

Week 9: Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network Fully Connected CNN etc.

Week 10: Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic segmentation Object Detection etc.

Week 11: LSTM Networks

Week 12: Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network