Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NECC504	Optimization Theory and Techniques	3	1	0	4

Course Objective
The objective of this course is to present the core mathematical concepts behind the theory and algorithms of mathematical optimization theory and discuss the working principles of iterative procedures to address convex as well as a few non-convex problems.
Learning Outcomes
Upon successful completion of this course, students will: • acquire a broad understanding of the mathematical concepts behind optimization theory and algorithms. • be able to design and analyze algorithms for solving several real-world optimization problems and • be prepared to venture into more advanced areas of optimization practice and research.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction and Review of Basic Real analysis and Linear Algebra**:** Basic problem of optimization, the black-box model; local and global optimization methods; zeroth, first and second order methods; Metric Spaces, open and closed sets, sequences, convergence; Concepts from vector spaces, linear independence, eigenvalues and eigenvectors.	9L+3T	The student will have an understanding of the basic problem in optimization and will be acquainted to the fundamental mathematical prerequisites.
2	Unconstrained optimization: global and local minima, convex sets and functions, first and second order optimality conditions; Smooth convex optimization, first and second order methods; Gradient descent and its variants; Applications in Signal processing and Machine Learning	9L+3T	The student will be introduced to the most basic theory and methods of unconstrained optimization and its applications
3	Constrained Optimization: The concept of Lagrangian and dual function; Karush-Kuhn-Tucker (KKT) points and duality; projected gradient descent	7L+2T	The student will have a good understanding of the basic constrained optimization method
4	Stochastic Optimization: Problem formulation, Concept of randomness for optimization, Stochastic Gradient Descent (SGD), Stochastic Variance Reduced Gradient Descent (SVRG), Applications in machine learning, large scale optimization, communication	8L+3T	The student will learn stochastic methods for optimization and its applications in machine learning and communication
5	Introduction to non-convex optimization: Motivation; Sparse recovery and non-convex projected gradient descent (PGD); introduction to the restricted strong convexity (RSC) and restricted strong smoothness (RSS) properties; the Majorization Minimization (MM) and the iterated hard thresholding (IHT), Stochastic IHT (StIHT)	9L+3T	The student will acquire a fundamental understanding of the problem of non-convex optimization through the problem of gradient descent for the sparse signal recovery problem
	Total:	42L+14T	

Text Book:

1. "Convex Optimization", Stephen Boyd and Lieven Vandenberghe, Cambridge University Press, 2004.

Reference Books:

1. "Lectures on Convex Optimization", Yuri Nesterov, Springer, 2018.
2. "Convex Optimization: Algorithms and Complexity", Sebastian Bubeck, NOW publishers, 2015.
3. "Non-convex optimization for Machine Learning", Prateek Jain and Purushottam Kar, NOW publishers, 2017.