

### Module 3: Univariate, Multivariate Calculus and Optimization

- 1 Graphs and Models.
- 2 Linear Models and Rates of Change.
- 3 Functions and their graphs.
- 4 Fitting models to data.
- 5 A preview of Calculus.
- 6 Finding limits graphically and numerically.
- 7 Evaluating limits analytically.
- 8 Continuity and One sided limits.
- 9 Infinite Limits.
- 10 The derivative and the tangent line problem.
- 11 Basic Differentiation rules and rates of change.
- 12 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 13 **Coding Assignment 10.**
- 14 Product and Quotient rule and higher order derivatives.
- 15 The chain rule.
- 16 Implicit Differentiation.
- 17 Increasing and Decreasing Functions and First Derivative test.
- 18 Concavity, Convexity, Non Convexity and Second Derivative test.
- 19 Unconstrained and Constrained Optimization Problems.
- 20 Convex Optimization Problems.
- 21 Solving Unconstrained Convex Optimization Problems
  - 21.1 First Order Algorithm : Gradient Descent Algorithm for Univariate Functions.
  - 21.2 Second Order Algorithm : Newton's Method for Univariate Functions.
  - 21.3 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
  - 21.4 **Coding Assignment 11.**
  - 21.5 Introduction to Multivariate Functions.
  - 21.6 Partial Derivatives.
  - 21.7 Directional Derivatives and Gradients.
  - 21.8 Tangent Planes and Normal Lines.
  - 21.9 Extreme Value Theorem for Multivariate Functions.
  - 21.10 First Order Algorithm : Gradient Descent Algorithm for Multivariate Functions.
  - 21.11 Second Order Algorithm : Newton's Method for Multivariate Functions.
  - 21.12 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
  - 21.13 **Coding Assignment 12.**
- 22 Solving Constrained Convex Optimization Problems
  - 22.1 Equality and Inequality Constraints, Active Sets and Binding Constraints.
  - 22.2 Feasible Sets, Feasible Points, Interior and Boundary Points.
  - 22.3 Barrier and Penalty Methods for solving Constrained Optimization Problems.
  - 22.4 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
  - 22.5 **Coding Assignment 13.**
  - 22.6 What is Primal Problem ?
  - 22.7 Primal Problem and its objective function.
  - 22.8 Introduction to the Dual to Primal problem.
  - 22.9 What is a Dual Problem ?
  - 22.10 Introduction to Dual Variables.
  - 22.11 Why Dual problem ?
  - 22.12 Duality.

- 22.12.1 Strong and Weak Duality.
- 22.12.2 Duality Gap.
- 22.13 Introduction to Lagrange Multipliers as Dual variables.
- 22.14 Construction of Lagrangian Function.
  - 22.14.1 Physical Significance.
  - 22.14.2 Importance.
  - 22.14.3 Derivative of Lagrangian Function.
- 22.15 Dual Problem and its objective function.
- 22.16 Necessary and Sufficient Conditions for Optimality.
- 22.17 Strict Complementarity and Degenerate case.
- 22.18 Karush-Kuhn-Tucker Complementarity Conditions.
- 22.19 Solving Primal Problem through Dual Problem.
- 22.20 **Sample Python code demonstration along with detailed explanation for Coding Assignment.**
- 22.21 **Coding Assignment 14.**
- 23 **Portfolio Project 3 on Univariate, Multivariate Calculus and Optimization.**