



Table of Contents

1 Entrance Survey

2 Course Overview

MO2.1 Plot results, utilizing Python, that effectively communicate conclusions.

MO2.2 Utilize object-oriented programming in Python to solve problems.

MO2.3 Effectively utilize Python and NumPy to manipulate and perform calculations involving vectors and matrices.

MO2.4 Describe what an initial value problem is and give examples occurring in modeling of physical systems.

MO2.5 Describe the behavior of the solution to $dx/dt = \lambda x$, from its explicit form $x_0 \exp(\lambda t)$.

MO2.6 Describe convergence and order of accuracy for numerical methods to solve initial value problems.

MO2.7 Describe and implement explicit and implicit numerical methods to accurately solve initial value problems, including an awareness of how multiple timescales impact the choice of explicit versus implicit methods.

MO2.8 Give examples of the need to solve linear and nonlinear systems of equations arising in the modeling and optimization of physical systems.

MO2.9 Describe Gaussian elimination for solving linear systems of equations, including its computational complexity.

MO2.10 Describe and implement the bisection for solving a nonlinear scalar equation and Newton-Raphson methods for solving a nonlinear system of equations.

MO2.11 Describe fundamental concepts of optimization problems including: objective functions; constraints; linear versus nonlinear; discrete versus continuous; local versus global minimizers.

MO2.12 Describe the gradient descent method for optimization of single-variable and multivariable objective functions. Implement gradient descent for single- and multi-variable cases.

MO2.13 Describe basic probability concepts such as random variable; distribution in the discrete and continuous cases; moments; joint, conditional, and marginal distributions; Bayes' law.

MO2.14 Describe basic statistical estimation concepts, such as sample mean, sample standard deviation, and confidence interval.

MO2.15 Describe and implement Monte Carlo sampling for sampling distributions in the context of physical models with randomness.