MAE 306 Notes

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Introduction

This document contains notes taken for the class MAE 306: Mathematics in Engineering II at Princeton University, taken in the Spring 2025 semester. These notes are primarily based on lectures by Professor Mikko Haataja. This class covers finite-difference, finite-element, and spectral methods for numerical solutions to the wave and heat equations. Since these notes were primarily taken live, they may contains typos or errors.

Chapter 1

Numerical Solving

An important application of numerical methods is the computation of solution sets of various kinds of equations. Here we cover methods that may be used for algebraic equations and linear equations.

1.1 Algebraic Equations

We first consider methods which may be used to solve algebraic equations; namely finding values of x such that

$$f(x) = 0$$

for an algebraic function f. An algebraic function is a polynomial with roots in a particular field (here, $\mathbb{R}$).

Example 1.1

Consider a sphere of radius R which falls through a fluid under the force of gravity. Suppose we wish to determine its terminal velocity. The drag force is given by

$$F_D = \frac{1}{2} C_D \rho V^2 \pi R^2$$

where C_D is the drag coefficient. C_D can be empirically approximated by

$$C_D = \left[0.63 + \frac{4.9}{\sqrt{\mathrm{Re}}} \right]^2$$

with Re denoting the Reynolds number, given by

$$\mathrm{Re} = \frac{\rho V R}{\eta(V)}$$