Math 405/607E, Section 101, Fall 2019

Numerical Methods for Differential Equations

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Audience: The course is intended for 3rd and 4th year students in Science, Engineering, Commerce, or a quantitive Arts programme who wish to learn the basic numerical techniques they will require in business, industry, or graduate school. The course will also be useful to graduate students who have not taken basic numerical methods courses as part of their undergraduate training and who need these skills to do their research.

Undergraduate Prerequisites: Math 405 has a prerequisite of one of Math 256, 257, or 316.

Graduate Credit: The graduate version (Math 607E) of this course has a prerequisite of some knowledge of differential equations (ordinary and partial). A project involving some more detailed numerical analysis or computation is required in addition to the undergraduate material.

Course Objectives: The primary objective of the course is to introduce the basic numerical techniques for solving ordinary and partial differential equations in a single course, which does not require any previous numerical courses as a prerequisite. The basic numerical methods (e.g. interpolation, numerical integration, numerical differentiation, numerical linear algebra and root finding) are introduced and then applied to the solution of ordinary and partial differential equations. This approach helps to contextualize the numerical methods and enables us to focus on applications of the methods to practical problems. Some elements of modern computing will be used (version control, cloud storage).

Text: No text. Written notes will be provided. Some suggestions of optional texts will be provided on the web page.

Material: Floating point approximation and condition number. Newton's method for nonlinear vector problems. Numerical optimization (Newton's method and steepest descent). Functional approximation by power series, piecewise polynomial and spectral techniques. Numerical integration (quadrature and Monte Carlo) and differentiation. Discretization techniques for differential equation boundary value problems: finite difference, finite element and spectral methods. Fast solution techniques: direct sparse solvers and iterative methods. Time stepping techniques for initial value problems. Computational implementation is an important aspect of the course.

Marks (Math 405): 40% final, 10% midterm and 50% assignments

Marks (Math 607E): 30% final, 10% midterm, 40% assignments and 20% final project

Midterm Date: Tuesday, October 15 in class.

Assignments: There will be five challenging assignments. Some computation will be required. MATLAB is a high level mathematical computation package that is suitable for these computations, but other packages or basic computer languages can be used.

Project: Required for the graduate version (Math 607E) of the course. Topics will be finalized the week after the midterm in consultation with the instructor. The project could be a computation related to the student's thesis work.