Math 502: Numerical Methods in Applied Mathematics

Winter 2024

Instructor:	Dr. Stathis Charalampidis	**Office:**	25-319 (Faculty Offices East)
Email:	echarala@calpoly.edu	**Phone:**	(805) 756-2465

Course Web Page: https://www.egcharalampidis.com/teaching/502_W24/math_502_W24/

Class Meetings:

- TR: 7:10-9:00am (38-148)

Office Hours: TR 11:15am-12:45pm, or by appointment.

Required Textbook:

- *Understanding and Implementing the Finite Element Method*, Author: Mark S. Gockenbach, Publisher: SIAM, 2006.

Extra References:

- *The Mathematical Theory of Finite Element Methods (3rd Edition)*, Authors: Susanne C. Brenner and L. Ridgway Scott, Publisher: Springer-Verlag, 2008.
- *Programming the Finite Element Method (5th Edition)*, Authors: I.M. Smith, D.V. Griffiths and L. Margetts, Publisher: Wiley & Sons, 2015.
- *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Author: Claes Johnson, Publisher: Dover Publications, 2009.

Objectives: This graduate course aims to introduce the Finite Element Method (FEM) for partial differential equations (PDEs). The FEM is a spatial discretization technique (alongside finite difference techniques and spectral methods) with various applications including fluid mechanics, engineering, and (generally) in mathematical modeling. After having an introduction to the mathematics of elliptic boundary-value problems (BVPs), we will discuss their weak formulation (based on different boundary conditions), and the Galerkin method. Then, we will cover piecewise polynomials that are used in FEM and convergence theorems, and move forward with the implementation of FEM in MATLAB. It is expected that students will develop the necessary background to read scientific papers on numerical PDEs, write FEM codes, and get familiarized with available FEM software including FreeFEM++, see: https://freefem.org/.

https://content-calpoly-edu.s3.amazonaws.com/math/1/documents/502.pdf

Class Material by Topic: During the quarter, we will cover the following topics from Gockenbach's book:

- Elliptic BVPs (Chapter 1)
- The weak form of a BVP (Chapter 2)
- The Galerkin method (Chapter 3)
- Piecewise Polynomials and the Finite Element Method (Sections 4.1-4.2)
- Convergence of the Finite Element Method (Section 5.1)
- Mesh data structures (Chapter 6)
- Programming the Finite Element Method using P^1 and P^2 Lagrange triangles (Chapter 7)
- If time permits, selective topics will be discussed:
  - Cubic (i.e., P^3) Lagrange triangles (Section 4.3)
  - Implementation of Lagrange triangles of arbitrary degree (Chapter 8)
  - The multigrid method (Chapter 13)
  - Adaptive mesh generation (Chapter 14)

Course Prerequisites: Math 344 or Aero 300, a college-level programming language, and graduate standing.

Homework and Exams: There will be (almost) weekly **written** homework assignments that will be posted on Canvas. Each assignment will consist of a group of problems that will be taken from Gockenbach's book, and your task will be to write up solutions and/or develop MATLAB codes for each one. There will be **one written in-class midterm exam** and **one written (in-class) final**. For their schedule, see below the "Important Dates" section of this document.

Grading Policy and Exams: Your final grade in this course is computed according to:

Attendance & Class Participation	5%
Homework	30%
Midterm	30%
Final Exam	35%

Important Dates and Academic Holidays:

Martin Luther King	Monday, January 15
(Monday schedule is followed on Tuesday, January 16)	
Midterm	TBD
Washington's Birthday	Monday, February 19
Last day of classes	Friday, March 15
Final Exam	Tuesday, March 19, 7:10am-10:00am

Class and Exams Policies:

- Please **turn off your phone** during lecture.
- **Photos or any type of recordings** during lecture **are prohibited** unless you have an official accommodation from the DRC.
- All exams are **paper and pencil** exams.
- All exams will be closed-book, and they are primarily based on the material we cover in class and the homework.
- Absolutely no formula sheets and class notes are allowed during midterm and final exams.
- If a calculator is needed during the exams, I will let you know in advance to bring one.
- Please inform me as soon as possible if you are seeking to make up missed work pursuant to the excusable reasons listed in the url below:

https://academicprograms.calpoly.edu/academicpolicies/class-attendance

Students with Disabilities: The University provides disability-related support services to qualified students through the Disabilities Resource Center (DRC). If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both me and the DRC (124-119) at (805) 756-1395, as early as possible in the term. In addition, and for your convenience, their website is:

https://drc.calpoly.edu/

Note that use of DRC services including testing accommodations requires prior authorization by the DRC and compliance with approved procedures. **Make sure you initiate any needed arrangements well in advance of an exam date**.

Diversity and Inclusion: I am fully committed to an academic environment that is free of bias against any group and I firmly believe in the value of diversity in people and ideas. My ultimate goal is to establish that this class is a welcoming environment to every-one regardless of gender identity, sexual orientations, color, race, ethnicity, or religious identity. The University and I do not tolerate discrimination. Please feel comfortable coming to me if at any point you ever feel uncomfortable for any reason.