Math 452: Numerical Analysis II

Spring 2023

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Course Web Page: https://www.egcharalampidis.com/teaching/452_S23/math_452_S23/

Class Meetings:

- Section 1 (MW): 8:10-10:00am (10-111)

Office Hours: MW 10:30-11:30am, or by appointment.

Required Textbook:

- *Finite difference methods for ordinary and partial differential equations*, Authors: Randall J. LeVeque, Publisher: Society of Industrial and Applied Mathematics (SIAM), 2007.

Additional References (depending on the topic)**:**

- *A First Course in Numerical Methods*, Authors: Uri M. Ascher and Chen Greif, Publisher: SIAM, 2011.
- *Solving Ordinary Differential Equations I* (second edition), Authors: E. Hairer, S.P. Nørsett and G. Wanner, Publisher: Springer Series in Computational Mathematics, Springer, 1993.

Objectives: This course is the second part of the Numerical Analysis sequence (Math 451-Math 452-Math 453) offered at Cal Poly San Luis Obispo, and it complements itself the topics covered in Math 451. In particular, the following topics (not necessarily in the order listed) will be covered: Finite difference schemes for steady-state boundary value problems, numerical methods for ordinary differential equations (ODEs) as well as methods for initial and boundary value problems (IVPs and IBVPs, respectively) containing partial differential equations (PDEs). The use of MATLAB will be adopted in this class where practical implementations of the methods discussed in this course will be presented. For your convenience, a detailed course outline containing the learning objectives for this class may be found at

https://content-calpoly-edu.s3.amazonaws.com/math/1/documents/452.pdf

Class Material by Topic: During the quarter, we will cover the following topics from the **main** textbook:

- Finite Difference approximations
- Steady states, i.e., time-independent solutions and BVPs
- Elliptic equations
- Iterative methods for sparse linear systems (review)
- IVPs for ordinary differential equations
- Convergence and zero as well as absolute stability for ODEs
- Diffusion equations and parabolic problems
- Advection equations and hyperbolic systems

Course Prerequisites: Math 451, or equivalent.

Programming Prerequisites: A solid foundation on programming. It should be noted that **MATLAB** will be used in class and for homework assignments. Of course you can use **any** programming language such as Julia, Python, Fortran, C/C++, and so on. There are a few PDF files (same as the ones used in Math 451) and links for help with MATLAB on the course web page.

Homework and Exams: There will be (almost) weekly **written** homework assignments including **computational tasks**. For the latter, you will have to include/attach your codes in your homework. Please make sure you include as many **comments** as possible in your codes such that they could be read and easily understood. For a complete list of all homework assigned to date, please visit the Canvas page for the course. Each assignment will consist of a group of problems and your task will be to write up solutions for each one and develop codes when the question is asking for doing so. **No late homework will be accepted.** Please keep in mind that you will be rewarded not only for getting a correct answer but most importantly for the structure and presentation of your work. Finally, struggling through a question in the homework and most particularly in a computational/programming task is not something unusual. Please make sure you start developing your codes way in advance in order you to check and debug your programs.

There will be **one midterm exam** and **one cumulative 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:

Homework	25%
Projects[a]	20%
Midterm	25%
Final Exam	30%

[a] See page 3 for details.

Important Dates and Academic Holidays:

First Day of Classes	Monday, April 3
In-class 5' project presentation	TBD
Midterm	Wednesday, May 3
Memorial Day	Monday, May 29
Last day of classes for Math 452	Wednesday, June 7
Group project presentations ...	Wednesday, June 7, 6:10-8:00pm (10-226)
Final Exam	Wednesday, June 12 (7:10-10:00am)

Class Policies:

- All exams are **paper and pencil** as well as **closed-book** exams.
- Please go through the cheating and plagiarism procedures by clicking here.
- You are respectfully asked for turning off your cell phones during class time and exams.
- **Attendance is mandatory**. However, an **excused absence** can be allowed only if the reason for your absence falls into any of the categories listed in the following page:

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

  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 above.

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 orientation, race, ethnicity, or religious identity. The University and I do not tolerate discrimination. Please feel comfortable coming to me or an administration if at any point you ever feel uncomfortable for any reason.

Group Projects

Group's setup and selection of a topic

Each student will join a 4-person group and the group will investigate a model described by an ODE/PDE and/or a topic from Numerical Analysis of their choice by using methods from Math 451 **and** Math 452. Your instructor will facilitate the formation of these groups, as well as the selection of suitable topics if necessary; but the students in each group will originate their topic of their project. The topic/ODE/PDE may be from any field, as long as it allows the student group to pursue a Numerical Analysis project. In addition, groups should use a programming language such as Java, Python, C++, etc., or a scientific computing software Mathematica, MATLAB or similar.

Required outcomes

There will be three required outcomes:

- An **in-class presentation of around 5 minutes** which will take place at the mid-quarter point. This is a group progress report which should include the following:
  - The topic/ODE/PDE chosen and why is it important.
  - What methods from Numerical Analysis will be used.
  - How the group will proceed to finalize its project.
- An **in-class presentation of around 20 minutes** (+ a few minutes for questions), given as a **prepared lecture with projector slides** (e.g., you can use PowerPoint or Beamer, if you are a LaTeX user). It should summarize:
  - The topic/ODE/PDE that you worked on with historical remarks/current state-of-the art.
  - What was the motivation for working on it.
  - How did the methods you used translate into mathematical terms.
  - How the results and conclusions are derived (include graphs, tables, etc.).
  - Any open questions.
- A **final paper** prepared by the entire group that reports the Numerical Analysis project (about 5 pages long and without counting any code–codes, if there are any, can be attached in an appendix). LaTeX would be useful for this purpose. In addition, each student will write and submit a **personal version** of the project report, even though it reports on joint work. Each students' report will include a **separate**, **one-page**, **reflection on his/her shared learning experience**. This reflection should answer questions such as:
  - What were your main contributions to the group project?
  - Were you able to draw on special knowledge that you acquired in the past?
  - Did your ideas, proposals or criticisms become incorporated into the report and presentation?
  - How did the interaction among group members influence the completion of the project?
  - Are you satisfied with the final result and with the group experience, including the contributions of the other members of your group?

Further yet important notes

- Both presentations **are done as a group**. The main goal of the presentations, is to explain your project to your fellow students. Make sure you spend enough time to explain the problem and give a quick summary of your findings in the final presentation.
- As per the final paper, I **do not** want three times the same paper.
- Please, be **precise** and **concise** while writing mathematics.
- Make sure to include **all** your sources by citing them appropriately in your final paper.
- If it happens that the computations involved are long, present your main finding(s) and put the computation in an appendix.
- Make sure to include your code(s) in an appendix.