Mathematical Modeling of Industrial Problems (Math8387)
Course Syllabus–Fall 2022

Class schedule: MWF 2:30-3:20, Vincent Hall 213

Instructor: M. Carme Calderer (www.math.umn.edu/mcc)
Office: VinH 507; email: calde014@math.umn.edu
Office Hours: Monday 4-5:30 pm; Thursday, 4:30-5:30 pm. Occasionally, the office hours will be held via zoom, subject to prior announcement.

Textbook:

All background calculus courses, through advanced calculus are required. Also, full and working knowledge of linear algebra and ordinary differential equations is required. Working knowledge of Matlab (or other mathematical software including Python) is also required. The use of *Firadrake*, a software for finite element simulation, is highly encouraged. You may go online to obtain a free version of it to install in your comuputer.

Your student account should allow you to download Matlab from the site:
https://cse.umn.edu/cseit/software/matlab

Course Objectives: This is a course on mathematical modeling of problems arising in the industry and it aims to finding relevant and applicable solutions. It is based on the premise that, from a new material or device embryo in someone's mind through its market deployment, mathematics enters in many steps. We will focus on the modeling stage, with emphasis on methods that come from first principles, and the mathematical solution of the model problems, including their numerical simulations. The components of the course are:

- A survey of continuum mechanics, including solid and fluid models.
- The former will allow us to study the theories of liquid crystals and elastic materials, including those of polymeric type.
- Mathematical foundations to solve the models. These will include calculus of variations and partial differential equations to address equilibrium problems, and also evolutionary equations to study time dependent systems. Dynamical systems will be also addressed as needed.
- A case study to illustrate the transfer from modeling and mathematical analysis to industry. We will focus in the industrialization of liquid crystal display devices.
- Problems from mathematical biology, specifically, models of bacteriophage viruses in novel antibiotic research, and active media to simulate the cytoskeleton will also be included, should there be interest from the students.

Course Materials:

- Two main books will be used for the PDEs and analysis components of the course: *Partial Differential Equations* by Lawrence C. Evans and *Introduction to Partial Differential Equations* by Peter J. Olver.

- *Mathematics Applied to Deterministic Problems in the Natural Sciences* by C.C. Lin and L.A. Siegel.
- *Progress in Industrial Mathematics at ECMI 2021, 2022* and earlier volumes. These are books from the Springer collection *Mathematics and Industry* publisehd by the European Consortium for Mathematics in Industry.
- Lecture notes posted by the instructor.
- Assigned research articles.

The above books are available in the Library.

Course Work: This is a course that requires continuous effort, from several aspects. The work will include:

- A bi-weekly homework assignment.
- One midterm examination.
- A team project, with final report and class presentation.

Each one of the above items counts towards 1/3 of the final grade.

Course Project: This is a very important part of the course. You will form student teams who will work together on the project throughout the semester. Each team of students will be responsible for completing a project and presenting the results in class. The project is to be selected from a list of topics to be provided by mid-September. Project timeline:

- September 30: Deadline for forming research teams.
- October 21: Deadline for submitting a project proposal with the research plan.
- November 18: Submission of a short progress report (three pages, at most).
- December 5: Submission of the completed project report.
- December 12 and 14: Proposal presentations.

Your presentation will be evaluated by the class instructor, who will assign a group grade to the project. The score will be based on the quality of the research, the report and the presentation. The group score will also be individually assigned to every student of the group. To help ensure success for everyone, teams should set expectations in the first team meeting, assign roles and duties, and hold each other accountable for performance, during the completion of the project and also in preparing for the final report and the presentation.

If the enrollment permits it, teams including students from different disciplines will be encouraged. The goal is to promote a realistic industrial research setting to model that in the work situation.

Academic Honesty and Student Code of Conduct. Academic dishonesty will be handled according to university policy, and a grade of F or N will be awarded for the course. In general, the Code of Conduct and all student policies as established by the University of Minnesota apply in this course.

Covid 19 protocols. Students are required to follow the rules and protocols established by the university, if any, to ensure health safety during the semester.