Computational Modeling in Engineering and the Sciences

Ashton Cole *

Fall 2025

Description

In this beginner-friendly group, we will broadly explore the field of computational modeling: the kind of work done at the Oden Institute (https://oden.utexas.edu). We will practice both reading papers and coding simple projects. Each meeting will consist of a discussion, lecture, and self-guided coding demo. Relevant literature will be assigned for reading between each session.

We will start with learning how to build and solve ordinary differential equations, then partial differential equations. Emphasis will be on applications in storm surge modeling, my area of research, but other groups and topics will be considered on the way. The semester will culminate in a mini-project solving the nonlinear Shallow Water Equations.

Goals

- **Learn about computational modeling.** We will explore at the surface level common modeling techniques and solution schemes used by engineers and scientists to model real-world problems.

- **Explore research and academia.** We will explore the work at the Oden Institute and resources available to students like the Texas Advanced Computing Center (https://tacc.utexas.edu).

- **Mentorship.** I am happy to be a resource for anyone interested in research and academia, whether that means an undergraduate job for a couple of semesters, or aspirations for professorships and tenure.

- **Build up math and coding skills.** Although participants are not expected to pursue hydraulics or even computational science, the techniques covered are broadly applicable. They should be useful exposure for any engineer, mathematician, or computer scientist.

  - Math skills: ODEs, PDEs, numerical solution techniques
  - Programming skills: Python, Jupyter, Conda, NumPy, control sequences, data structures, vectorization, visualization, file I/O

- **"Leave things better than we found them."** If anything, this is a chance to try new things, discover your interests, and grow as a person.

Prerequisites

- Required

  - Programming fundamentals
  - Calculus

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*Graduate Research Assistant, Computational Hydraulics Group
Oden Institute for Computational Engineering & Sciences
ashtonvcole@utexas.edu

- – Understanding of basic matrix operations
- – Willingness to learn new things

- Recommended

  - – Python
  - – Vector calculus
  - – Linear algebra
  - – Differential equations
  - – Interest in domain outside of computer science, e.g. physics

Schedule

A tentative schedule is provided below, subject to change based on need and mentee feedback. Fewer sessions than weeks are scheduled in anticipation of conflicts and end-of-semester chaos.

	Date	Paper	Lecture	Demo
1		N/A	Overview of DiRP	Setup of Python, conda, Jupyter, NumPy
2		Something about COVID	Scalar ODEs, integration techniques, error analysis	Population dynamics
3		Something from Stella	General ODEs	Computational chemistry
4		Something from Moriba Jah	Formulating two-body problem	Astrodynamics
5		Something HPC	HPC and TACC	TACC "tour"
6		Something quantum	PDEs and solution techniques	Scalar advection equation
7		Something from cardiology or oncology	Transport equations	Fun PDEs I
8		Something by Dawson	Computational hydraulics and Shallow Water Equations	Fun PDEs II
9		Something by Dawson	Constructing a simulation	SWE I
10		Something by Dawson	Postprocessing	SWE II

special days acoustics and waves pdes and transport?? TACC