SIOG 239 Practical PDEs

Spring 2024

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1. Objectives

This class is intended to be a first course in Partial Differential Equations for graduate students in Geophysics (GP). No mathematical prequisites are requried or assumed.

In this course you will learn to see the world through a lens of Partial Differential Equations (PDEs). You will become familiar with the form, solution type associated with classical (generic) PDEs. The diversity of PDEs used in Geophysics will be explored.

At the end of this course you will:

- Be familiar with partial derivatives, how to compute them;
- Be comfortable with the different types of notation used to describe partial differential equations;
- Understand the solution types different PDEs admit;
- Have familiarity with linear and non-linear PDEs;
- Awareness of which numerical methods can be used to solve specific types of PDEs;
- Speak and understand the mathematical language used to describe PDEs.

2. Schedule

- Two lectures per week (19 lectures in total):
    - Tuesday 12:30 - 13:50 | Eckart 236
    - Thursday 12:30 - 13:50 | Eckart 236
- There will be no lecture on:
    - Tuesday April 23

- Exam is scheduled for:
    - Friday June 14, 11:30 - 14:30 | Location TBD

3. Topics

Below is a tentative (ordered) list of topics we will examine:

- Preliminaries: Numbers, sets, intervals, domains, functions, continuity, limits, the derivative.
- Ordinary differential equations.
- Multi-variable quantities: Notation, derivatives.
- Differential operators: Scalars quantities.
- Tensors: Notation, identities, examples.
- PDEs in Geophysics.
- PDE manipulations.
- Canonical PDEs (elliptic, hyperbolic).
- Canonical PDEs (parabolic). PDE classification.
- Well-posed problems.
- Principal of linear super-position.
- Dimensional analysis, dynamic similarity.
- Nonlinear PDEs.
- Perturbation analysis.
- Weak solutions.
- Method of Manufactured Solutions.
- Adjoints, Gateaux derivatives.
- Numerical methods of choice for PDEs.

4. Assessment

The assement is progressive and distributed over the quarter. The breakdown of the assessment is as follows.

- **70% Homework assignments (5 in total)**
- **30% Final exam**

Below is the homework schedule

Task	Release date	Due date
Homework 1	Apr-11	Apr-18
Homework 2	Apr-25	May-02
Homework 3	May-09	May-16
Homework 4	May-23	May-30
Homework 5	May-30	Jun-06

All assessments are to be submitted via Canvas.

5. Resources

- Walter A. Strauss (1992). *Partial differential equations: An introduction*. John Wiley & Sons
- Lawrence C. Evans (2022). *Partial differential equations* (Vol. 19). American Mathematical Society.
- Erwin Kreyszig (2007). *Advanced Engineering Mathematics* 9th Edition. John Wiley & Sons.
- Kenneth F. Riley, Michael P. Hobson, and Stephen J. Bence (2006). *Mathematical methods for physics and engineering: A comprehensive guide*. Cambridge University Press

Other material will be provided via Canvas.

6. Academic Integrity

All coursework that you will produce in this unit should be original work that is yours alone. Copying work or the re-use of any material without proper acknowledgement or attribution is considered plagiarism. At UCSD, plagiarism is not acceptable.

Guidelines for giving proper acknowledgement or attribution to others work is provided below.

Group work

- If you worked in a group, you need to indicate all people involved in the group work and clearly state what your contributions were.
- If you use material from another student, you need to indicate who the student was and detail exactly what material was re-used and state clearly any modifications you made to their work.

Online resources

- If you used a tutorial in any capacity, you must provide the URL (web address) of the original material and indicate that you used an online resource as part of your submitted work. You must indicate which parts of the tutorial you used.
- If you used a script, or piece of computer code (e.g. taken from a tutorial, or a site such as StackOverflow) you must provide the URL of the original material. You must submit the original script / code in the form of an appendix with your submission. You must also indicate if you did, or did not, modify the original material. If you modified the original material, you must detail the modifications made. Care must be taken to ensure that the website and or authors copyright policy on the script / code is not violated. If in doubt please consult your instructor.
- Complete answers to any practice problem or homework assignment which are generated by ChatGPT are not considered "original work that is yours alone". You may use ChatGPT to debug you own code, and as a help resource (like you would a tutorial). You may also use ChatGPT to verify the correctness of your own code. If you do use ChatGPT in any capacity for a submission, please indicate this in your submission and provide the exact query you used.

7. Students with Disabilities

Students requesting accommodations for this course due to a disability must provide a current Authorization for Accommodation (AFA) letter issued by the Office for Students with Disabilities (OSD) which is located in University Center 202 behind Center Hall. Students are required to present their AFA letters to faculty (please make arrangements to contact the instructor privately) and to the OSD Liaison in the department in advance so that accommodations may be arranged. Contact the OSD for further information [phone] 858-534-4382; [email] osd@ucsd.edu, [website] https://disabilities.ucsd.edu.

8. Student Affairs

Throughout your time at UC San Diego, you may experience a range of issues that can negatively impact your learning. These may include physical illness, housing or food insecurity, strained relationships, loss of motivation, depression, anxiety, high levels of stress, alcohol and drug problems, interpersonal or sexual violence, or grief. Such issues may lead to diminished academic performance and affect your ability to participate in day-to-day activities. If there are issues related to coursework that are a source of particular stress or challenge, you may speak with your instructor, so that they are able to support you. UC San Diego provides several resources available all enrolled students, including:

- Counseling and Psychological Services: [phone] 858-534-3755, [website] https://caps.ucsd.edu
- Student Health Service: [phone] 858-534-3300, [website] https://studenthealth.ucsd.edu
- CARE at the Sexual Assault Resource Center: [phone] 858-534-5793, [website] https://care.ucsd.edu
- The Hub Basic Needs Center: [phone] 858-246-2632, [website] https://basicneeds.ucsd.edu

9. Copyright

All course materials (class lectures and discussions) and the intellectual content of the course itself are protected by United States Federal Copyright Law, the California Civil Code. The UC Policy 102.23 expressly prohibits students (and all other persons) from recording lectures or discussions and from distributing or selling any course materials without the prior written permission of the instructor. Students are permitted to make notes solely for their own private educational use. Exceptions to accommodate students with disabilities may be granted with appropriate documentation. See https://policy.ucop.edu/doc/2710530/PACAOS-100.