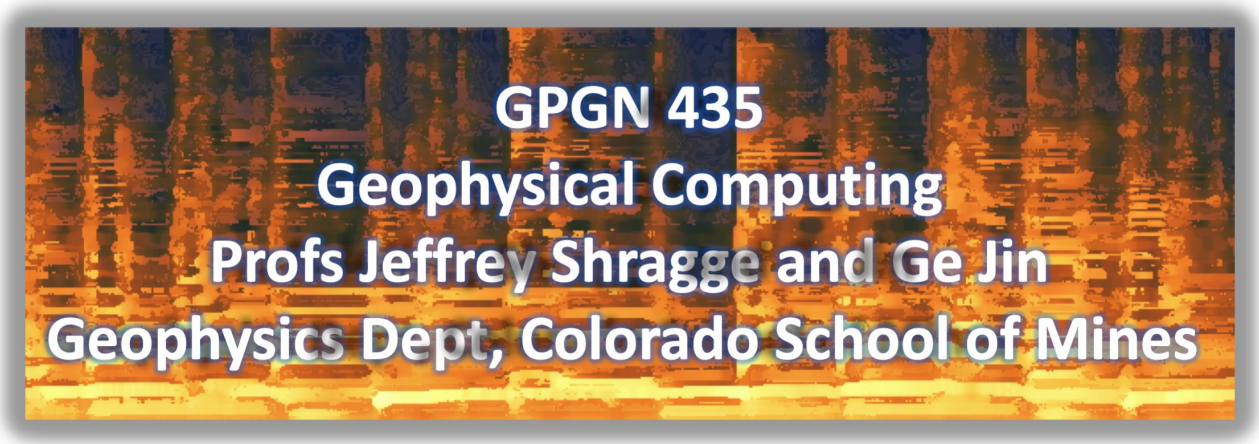

GPGN 435 Syllabus - Geophysical Computing

Prerequisites: CSCI250

Co-instructors:

- Profs Jeffrey Shragge and Ge Jin, Geophysics Department

Contact Information (O/P/E):

- JS: Green Center Room 241, jshragge@mines.edu (mailto:jshragge@mines.edu) , 303.273.3552
- GJ: Green Center Room 253, gjin@mines.edu (mailto:gjin@mines.edu), 303.273.3455

Class meeting days/times/locations:

- Lectures: Tuesday/Thursday 1100-1150h in Alderson Hall 230
- Labs : Thursday 1200-1400h in Green Center 228

Office hours:

- JS: Thursdays 930-1100h
- GJ: Thursdays 930-1100h
- Limited availability outside these hours by email request.

Teaching Assistant:

- TBD

Instructional Activity:

- 2 hours lecture
- 2 hours lab
- 3 semester hours

Course Designation:

- GPGN Major Requirement

Course Description from Bulletin

This course develops the principles of geophysical computing in the context of simulating and validating numerical solutions to the types of partial differential equations commonly found in geophysical investigations (e.g., potential fields, heat flow/diffusion, seismic wave propagation). Students are introduced to architecture of modern computing systems and learn how algorithms can be developed to leverage this architecture to efficiently generate numerical solutions to multidimensional geophysical problems using parallel computing methods.

Learning Outcomes

This senior-level undergraduate course builds on analytical geophysical and numerical/computational skills learned in previous years by applying them in the context of common geophysical computing challenges. Major objectives of the course include:

1. Students will understand and be able to apply concepts of computing in the context of solving complex geophysical problem, many involving field data.
2. Students will develop practical programming skills and combine with knowledge of numerical algorithms to solve real-world geophysical problems.
3. Students will develop independent research skills by undertaking a project involving a substantial piece of analytic, numerical and computation work involving solving a real-world geophysical problem
4. Independently design, develop, validate and apply computer programs to solve geophysical data analysis and numerical modeling tasks, largely using the Python language and its associated tool kits (i.e., Numpy, Scipy and Matplotlib).

Course Assessment procedures

The course will be assessed according to the following:

- Quizzes (40%) - Generally held on Thursdays in class.
- Labs (40%) - Thursdays. Due on Wednesdays at 11.59pm.
- Final Project (20%) - Due at end of term.

Course Schedule (Timeline subject to revision)

- Week 1 (Aug 20 and 22)
  - 00 Introduction
  - 01 1D Interpolation
  - Lab 1 - 1D Interpolation
- Week 2 (Aug 27 and 29)
  - 01 1D Interpolation
  - 02 2D Interpolation
  - Quiz 1 (Aug 29): 1D Interpolation
  - Lab 2: 2D Interpolation
- Week 3 (Sept 3 and 5)
  - 03 Numerical Quadrature
  - Quiz 2 (Sept 5): 2D Interpolation
  - Lab 3: Numerical Quadrature
- Week 4 (Sept 10 and 12)
  - 04 Applied Linear Algebra for Geophysical Problems
  - Quiz 3 (Sept 12): Numerical Quadrature
  - Lab 4: Applied Linear Algebra I
- Week 5 (Sept 17 and 19)
  - No Class or Labs - SEG Week
- Week 6 (Sept 24 and 26)
  - 04 Applied Linear Algebra for Geophysical Problems
  - Quiz 4 (Sept 26): Applied Linear Algebra I
  - Lab 5: Applied Linear Algebra II
- Week 7 (Oct 1 and 3)
  - 05 Regression
  - Quiz 5 (Oct 3): Applied Linear Algebra II
  - Lab 6: Regression
- Week 8 (Oct 8 and 10)
  - 06 Ordinary Differential Equations (ODEs)
  - Quiz 6 (Oct 10): Regression
  - Lab 7: Ordinary Differential Equations (ODEs)
- Week 9 (Oct 17)
  - No Class on Oct 15
  - 07 Differentiation and Discretization
  - Quiz 7 (Oct 17): Ordinary Differential Equations (ODEs)
  - Lab 8 (Mar 07): Differentiation and Discretization
- Week 10 (Oct 22 and 24)
  - 07 Differentiation and Discretization
  - NO QUIZ THIS WEEK
  - Lab 9: Differentiation and Discretization
- Week 11 (Oct 29 and 31)
  - 08 Elliptical PDEs
  - Quiz 8 (Oct 31): Differentiation and Discretization
  - Lab 10: Numerical Solutions of Elliptical PDEs
- Week 12 (Nov 5 and 7)
  - 09 Parabolic PDEs
  - Quiz 9 (Nov 7): Elliptical PDEs
  - Lab 11: Numerical Solutions of Parabolic PDEs
- Week 13 (Nov 12 and 14)
  - 09 Parabolic PDEs
  - 10 Hyperbolic PDEs
  - Quiz 10 (Nov 14): Parabolic PDEs
  - Lab 12: Numerical Solutions of Hyperbolic PDEs I
- Week 14 (Nov 19 and 22)
  - 10 Hyperbolic PDEs
  - Quiz 11 (Nov 22): Hyperbolic PDEs
  - Lab 12: Numerical Solutions of Hyperbolic PDEs II
- Week 15 (Nov 26)
  - NO CLASS ON NOV 28 (THANKSGIVING)
  - 10 Hyperbolic PDEs
  - NO QUIZ OR LAB
  - PROJECT WORK

- Week 16 (Dec 3 and 5)
  - No classes - Dead week
  - No Quizzes or Labs
  - **FINAL PROJECTS DUE: Friday December 6 @ 11.59pm**

Recommended Resources

- **Course Materials:** You will be provide a set of **Jupyter Notebooks** that contain the course notes and reproducible DSP Python code examples that use the powerful Numpy, Scipy and Matplotlib packages.
  - Course materials are available at: https://github.com/jshragge/CSM_GP_GEOPCOMP (https://github.com/jshragge/CSM_GP_GEOPCOMP)
  - You will receive "handouts" for lab assignments in electronic format.
- *Advanced Engineering Mathematics*, 3rd Edition, by Erwin Kreyszig.
  - **Recommended but Optional:** This textbook covers both the analytical mathematical physics behind much of the couse material as well as the numerical section. It is recommended as a good survey EngMath textbook at senior undergraduate level.

Delivery mode/Pedagogy

The material is presented through two one-hour lectures per week, and one two-hour lab session per week and through self-study. Students will be provided with the material (**Jupyter Notebook**) before classes and are expected to read through and reproduce worked examples before class. These notebooks use short **Python** examples to illustrate the concepts introduced in class. Class time is focused on clarification and going through key concepts and examples.

How to get help?

You should not hesitate to seek our help, and can do this in the following ways:

1. Ask questions in class. Never hesitate to ask, even if we have explained material before. You can safely assume that if something is not clear to you, there are several classmates that have the same question. We will also answer questions related to homework.
2. Drop by our office. While we travel much and are busy, you need not hesitate to come by with questions. I will not use email to answer questions about the material covered, but will use email to agree on a meeting time.
3. Use the course SLACK channel to contact us.
4. Seek the help of the Teaching Assistant.
5. We will not provide help for homework through email (but you can use email to arrange a meeting time). If anything is not clear, or if you need help, ask in a timely way using any of the three options above.

Coursework Return Policy

Quiz and lab results will be returned within one week.

Late Submission Policy

Materials submitted late will receive a 10% late penalty per calendar day. However, being reasonable people, we are willing to provide short extensions provided that a reasonable request is submitted at least 24 hours in advance of the deadline.

Absence Policy (e.g., Sports/Activities Policy)

All students are advised to be familiar with CSM's policy regarding the make-up of work missed due to excused absences. This policy may be found in the Bulletin. If a student is ill and exhibits flu-like symptoms, they should not attend class, labs, or exams. In order for an absence based on illness to be excused, the student must normally communicate directly with the Associate Dean of Students or his/her instructors. In all cases of unexcused absences the faculty member has the right to deny the student the opportunity to make up all or part of the missed work. **Coursework must be turned in before it is due to be graded – plan ahead.**

Diversity and Inclusion

At Colorado School of Mines, we understand that a diverse and inclusive learning environment inspires creativity and innovation, which are essential to the engineering process. We also know that in order to address current and emerging national and global challenges, it is important to learn with and from people who have different backgrounds, thoughts, and experiences. Our students represent every state in the nation and more than 90 countries around the world, and we continue to make progress in the areas of diversity and inclusion by providing Diversity and Inclusion programs and services (https://www.mines.edu/about/diversity-and-inclusion/) to support these efforts.

Students with Disabilities

The Colorado School of Mines is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you anticipate or experience any barriers to learning in this course, please feel welcome to discuss your concerns with me. Students with disabilities may also wish to contact Disability Support Services (DSS) to discuss options to removing barriers in this course, including how to register and request official accommodations. Please visit their website at disabilities.mines.edu (disabilities.mines.edu) for contact and additional information. If you have already been approved for accommodations through DSS, please meet with me at your earliest convenience so we can discuss your needs in this course.

Discrimination, Harassment and Title IX

All learning opportunities at Mines, including this course, require a safe environment for everyone to be productive and able to share and learn without fear of discrimination or harassment. Mines' core values of respect, diversity, compassion, and collaboration will be honored in this course, and the standards in this class are the same as those expected in any professional work environment. (More information can be found here

(http://inside.mines.edu/UserFiles/File/FacultySenate/Documents/ValuesAndAspirationsStatement2-14-17.pdf).) **Discrimination or harassment of any type will not be tolerated.** As a participant in this course, we expect you to respect your instructor and your classmates. As your instructor, it is my responsibility to foster a learning environment that supports diversity of thoughts, perspectives and experiences, and honors your identities.

To help accomplish this:

- Course rosters are provided to the instructor with the student's legal name. I will honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records.
- If something is said or done in this course (by anyone, including myself) that made you or others feel uncomfortable, or if your performance in the course is being impacted by your experiences outside of the course, please report it to:
    - Me (if you are comfortable doing so)
    - Wellness Center - Counseling (https://www.mines.edu/counseling-center/)
    - Speak Up - Anonymous Option (https://www.mines.edu/speak-up/)

In this course, we will cultivate a community that supports survivors, prevents interpersonal violence, and promotes a harassment free environment. Title IX and Colorado State law protects individuals from discrimination based on sex and gender in educational programs and activities. Mines takes this obligation seriously and is committed to providing a campus community free from gender and sex-based discrimination. Discrimination, including sexual harassment, sexual violence, stalking, and domestic violence, is prohibited and will not be tolerated within the Mines campus community. If these issues have affected you or someone you know, you can access the appropriate resources on the Mines Title IX website (https://www.mines.edu/title-ix/). You can also contact the Mines Title IX Coordinator, Camille Torres, at 303.384.2124 or titleix@mines.edu (titleix@mines.edu) for more information.

It's on us, all of the Mines community, to engineer a culture of respect

CARE @ Mines

If you feel overwhelmed, anxious, depressed, distressed, mentally or physically unhealthy, or concerned about your wellbeing overall, there are resources both on- and off-campus available to you. If you need assistance, please ask for help form a trusted faculty or staff member, fellow student, or any of the resources below. As a community of care, we can help one another get through difficult times. If you need help, reach out. If you are concerned for another student, offer assistance and/or ask for help on their behalf. Students seeking resources for themselves or others should visit care.mines.edu (care.mines.edu).

Additional suggestions for referrals for support, depending on comfort level and needs include:

- CARE at Mines (care.mines.edu)– for various resources and options, or to submit an online "CARE report" about someone you're concerned about (email: care@mines.edu (care@mines.edu)).
- CASA (https://www.mines.edu/casa) – for academic advising, tutoring, academic support, and academic workshops.
- Counseling Center (https://www.mines.edu/counseling-center/) – for students to call 303-273-3377 for an appointment. There are also online resources for students on the website. Located in the Wellness Center 2nd floor at 1770 Elm St.
- Health Center (https://www.mines.edu/student-health/) – students may call 303-273-3381 for appointment. Located in Wellness Center 1st floor at 1770 Elm St.
- Colorado Crisis Services (http://coloradocrisisservices.org) – for crisis support 24/7, either by phone, text, or in person. Colorado Crisis Services is a great confidential resource, available to anyone by calling 1-844-493-8255, or texting "TALK" to 38255. Walk-in location addresses are posted on the website.

All of these options are available for free for students. The Counseling Center, Health Center, and Colorado Crisis Services are confidential resources. The Counseling Center will also make referrals to off-campus counselors, if preferred.

In an emergency, you should call 911, and they will dispatch a Mines or Golden PD officer to assist.

Policy on academic integrity and misconduct

The Colorado School of Mines affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining an fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives and the substance of the degrees it awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

Academic misconduct is the intentional act of fraud, in which an individual seeks to claim credit for the work and efforts of another without authorization, or uses unauthorized materials or fabricated information in any academic exercise. Student Academic Misconduct arises when a student violates the principle of academic integrity. Such behavior erodes mutual trust, distorts the fair evaluation of academic achievements, violates the ethical code of behavior upon which education and scholarship rest, and undermines the credibility of the university. Because of the serious institutional and individual ramifications, student misconduct arising from violations of academic integrity is not tolerated at Mines. If a student is found to have engaged in such misconduct sanctions such as change of a grade, loss of institutional privileges, or academic suspension or dismissal may be imposed.

The complete policy is online (http://inside.mines.edu/POGO-Student)