UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

Department of Earth, Energy, and Environment
ES 118
403 220-5841
earth@ucalgary.ca

COURSE OUTLINE

1. **Course:** GOPH 420, Inversion and Parameter Estimation for Geophysicists - Winter 2024

   Lecture 01 : TR 15:30 - 16:45 in SA 219

Instructor	Email	Phone	Office	Hours
Dr Brandon Karchewski	brandon.karchewski@ucalgary.ca	403 220-6678	ES 108	By Appointment

   Teaching Assistant:
   Ji Li, *Email:* li.ji1@ucalgary.ca

   To account for any necessary transition to remote learning for the current semester, courses with in-person lectures, labs, or tutorials may be shifted to remote delivery for a certain period of time. In addition, adjustments may be made to the modality and format of assessments and deadlines, as well as to other course components and/or requirements, so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff).

   In Person Delivery Details:

   Lectures: The lectures will be in-person at the registrar-scheduled time (TuTh 15:30-16:45) in ES 242. You are highly encouraged to attend the in-person class sessions as they will involve interaction/discussion about the content. The in-person class sessions will not be recorded.

   Labs: The labs will be in-person once per week (Tu 8:00-10:50) in ES 924 beginning Tue Jan 16. The lab sessions will include a mix of demonstrations of computation tools and techniques, numerical examples of course topics, and work time for lab assignments. The lab sessions will provide opportunity to discuss/collaborate on the assignments with your peers and you are highly encouraged to attend. The lab descriptions/exercises/assignments, including instructions on how to submit your assignments, will be uploaded to D2L. As you work through the labs, you are welcome to ask questions of the instructor, TA, and/or your peers during lab sessions or via email. Appropriate collaboration is encouraged, but everyone will submit their own lab assignment.

   Quizzes and Exams: Quizzes will be posted to D2L throughout the term and you will typically have one week to complete multiple attempts of each quiz. The midterms will be online asynchronous and will be scheduled for a "2 hour" timeslot (concurrent with the lab period). Both exams will be posted to D2L 24 hours before the end of the scheduled time and will be due for electronic submission at the end of the day on the corresponding Tuesday. There will not be a Registrar-scheduled final exam.

   Course Site:

   D2L: GOPH 420 L01-(Winter 2024)-Inversion and Parameter Estimation for Geophysicists

   Note: Students must use their U of C account for all course correspondence.

   Equity Diversity & Inclusion:

   The University of Calgary is committed to creating an equitable, diverse and inclusive campus, and condemns harm and discrimination of any form. We value all persons regardless of their race, gender, ethnicity, age, LGBTQIA2S+ identity and expression, disability, religion, spirituality, and socioeconomic status. The Faculty of Science strives to extend these values in every aspect of our courses, research, and teachings to better promote academic excellence and foster belonging for all.

2. **Requisites:**

   See section 3.5.C in the Faculty of Science section of the online Calendar.

   Prerequisite(s):
   Mathematics 211; and Mathematics 267 or 277; and Geophysics 351 or 355; and 3 units from Computer Science 217, 231, 235 or Data Science 211.

3. **Grading:**

   The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar.

   In determining the overall grade in the course the following weights will be used:

Course Component	Weight	Due Date (duration for exams)	Modality for exams	Location for exams
Lab Assignments (4)[1]	40%	Ongoing		
Quizzes (4-5)[2]	20%	Ongoing		
Midterm 1[3]	20%	Feb 27 2024 at 08:00 am (2 Hours)	online	ES 924
Midterm 2[4]	20%	Apr 09 2024 at 08:00 am (2 Hours)	online	ES 924

[1] Due: Lab #1: Fri Feb 2, Lab #2: Ongoing (evaluated by participation with git commits), Lab #3: Fri Mar 1, Lab #4: Fri Apr 5
[2] Due: Fri Jan 26, Fri Feb 16, Fri Mar 8, Fri Mar 22, Fri Apr 5
[3] Online asynchronous, lab period provided as office hours
[4] Online asynchronous, lab period provided as office hours

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	90 %	85 %	80%	75%	70 %	65 %	62%	60%	55 %	50 %

The University of Calgary offers a flexible grade option, Credit Granted (CG) to support student's breadth of learning and student wellness. Faculty units may have additional requirements or restrictions for the use of the CG grade at the faculty, degree or program level. To see the full list of Faculty of Science courses where CG is not eligible, please visit the following website: https://science.ucalgary.ca/current-students/undergraduate/program-advising/flexible-grading-option-cg-grade

4. **Missed Components Of Term Work:**

In the event that a student legitimately fails to submit any online or in-person assessment on time (e.g. due to illness, domestic affliction, etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date, or possible exemption and reweighing of components. Absences not reported within 48 hours will not be accommodated. Students may be asked to provide supporting documentation (Section M.1) for an excused absence, See FAQ.

If an excused absence is approved, options for how the missed assessment is dealt with is at the discretion of the coordinator or course instructor. Some options such as an exemption and pro-rating among the components of the course may not be a viable option based on the design of this course.

5. **Scheduled Out-of-Class Activities:**

There are no scheduled out of class activities for this course.

6. **Course Materials:**

Recommended Textbook(s):

> Chapra, S.C. and Clough, D.E., *Applied Numerical Methods with Python for Engineers and Scientists, 1e (ISE)* : McGraw Hill.
> Downey, A.B., *Think Python 2e*: Green Tea Press.

These texts will be the reference for the content of this course, and they are recommended, but not required. The instructor will post supplemental notes on D2L (https://d2l.ucalgary.ca/login.asp). You will be expected to stay up-to-date with the online content of the course on a weekly basis.

For in-class quizzes and term tests, you may use course notes, online reference and any calculator (including Python or Excel). Several software packages will be needed during the course and instructions will be provided on D2L and in class on how to obtain these, but in case you would like to get started on your own you will need:

- **Python 3.8+** (and **matplotlib**, **NumPy**, and other packages). This is free, open-source software available from a variety of sources. Some options to consider are (ordered in terms of recommended preference):
  - Install using **pyenv [https://github.com/pyenv/pyenv] (or pyenv-win [https://github.com/pyenv-win/pyenv-win])** which allows managing multiple different versions of Python and along with the **virtualenv** package helps to organize and manage isolated environments for each project to make it easier to document and test package dependencies. This is especially important/useful on *NIX type operating systems (such as macOS and any Linux distro) that typically also have a system version of Python that it is best practice to keep separate from your individual project environments.
  - **Anaconda [https://www.anaconda.com/products/distribution]**, which includes Python 3 with many useful packages for scientific computing pre-loaded and a package manager built-in for installing other Python packages. The Anaconda distribution also includes multiple free integrated development environment (IDE) options including Jupyter notebooks (free), Spyder (free), and PyCharm (free Edu version).

    - "Vanilla" **Python 3** for your OS (e.g. **https://www.python.org/downloads/** or using a command line install method). With this method, you should also ensure to use the built-in Python **venv** package or the more feature-rich **virtualenv** package to keep development environments for each project separate from each other and the system Python. The **venv** tool has been built-in since Python 3.5, but the **virtualenv** package should be installed using the Python package manager **pip**.
- **git** version control package. This is free, open-source software which also has several possibilities for installation:
    - Windows:
        - If you have not previously used git, it is unlikely that it is pre-installed on Windows. There are multiple options to install it:
            - Use the **choco [https://chocolatey.org/]** package manager and then using a Windows Terminal / PowerShell opened with administrator privileges **choco install git** (or first **choco install gsudo**, and then in a non-admin terminal session **gsudo choco install git**). You can also install and manage updates on other useful software with choco (e.g. **gsudo choco install pyenv-win**, **gsudo choco install vim**, and/or **gsudo choco install notepadplusplus**). Once installed, the **git** command should be available from the Windows Terminal, PowerShell, or Command Prompt (you may have to type **refreshenv** or close and re-open your terminal first). Try **git --version** and make sure you get a result (e.g. **git version 2.37.2.windows.2**) to check that it is installed properly.
            - If you do not want to install a package manager you can use **Git for Windows** which also comes with a package of other tools including a *NIX-like terminal shell BASH. Follow instructions at **https://git-scm.com/download/win**.
    - Linux:
        - It is highly likely that your distro comes with **git** pre-installed; try **git --version** to check. If not, installation should be easy (e.g. **sudo apt install git** on Ubuntu/Debian, **sudo pacman -S git** on Arch-like distros). There are instructions for your distro at **https://git-scm.com/download/linux**.
    - macOS:
        - It is also possible that **git** is already installed; try **git --version** to check. If not, follow instructions at **https://git-scm.com/download/mac**. You may need to install a package manager such as homebrew first.
- A **text editor and/or IDE** for Python. Some popular options include:
    - **VS Code [https://code.visualstudio.com/]** is a free, open-source IDE with lots of available plugins for Python. The core package is maintained by Microsoft, but many of the plugins are developed by others in the open-source community, and it runs on any major OS (Windows, macOS, most popular Linux distros).
    - IDEs included with Anaconda such as **Spyder**, **PyCharm**, or **Jupyter** notebooks. Spyder and PyCharm are true IDEs like VS Code that include code auto-completion and auto-indentation among other features and access to a terminal prompt within the same program. Jupyter notebooks are a relatively simple environment that runs in your web browser, but they allow you to create multiple cells of different types (including Markdown for producing descriptive reports between your Python code cells), but lack many features common in IDEs such as auto-completion and auto-indentation. Jupyter notebooks can also be susceptible to bugs that are difficult to track down such as code that does not run depending on the order of execution of cells. VS Code also has support for Jupyter notebooks and provides the additional functionality that is lacking in the "vanilla" Jupyter notebooks that come with Anaconda.
    - **Notepad++** [**https://notepad-plus-plus.org/** or **https://github.com/notepad-plus-plus/notepad-plus-plus**] is a free, open-source text editor that is highly customizable and has syntax templates and auto-detection for every common programming language, including Python. Unlike VS Code/Spyder/PyCharm, this option is not an IDE, just a text editor, so you would need to run your code from a separate terminal/shell window, but this is fairly straightforward. It is mostly targeted at Windows systems, and technically there are options to install it on Linux and macOS, although it may not be the best option.
    - **Vim** [**https://www.vim.org/** or **https://github.com/vim/vim**] or **Neovim** [**https://neovim.io/** o r **https://github.com/neovim/neovim**] which are free, open-source, cross-platform, and highly configurable text editors. They run directly in a terminal or through a GUI. In their basic form, like Notepad++, these are mainly texts editors, so if using this option it is highly recommended to install additional plugins [e.g. Vundle https://github.com/VundleVim/Vundle.vim for Vim or LazyVim https://github.com/LazyVim/LazyVim for NeoVim] to unlock IDE-like capabilities. There exist many good tutorials on how to setup and use these programs, and you are encouraged to seek them out if choosing this option.

Information, examples, and tutorials for Python and other packages listed above will be provided in-class and during labs. You should already have some background with Python 3 from your introductory computer science course(s) (CPSC 217 or equivalent and GOPH 419 if you took it previously), but if you need a refresher the text Think Python 2e by A.B. Downey provides a concise and clear overview of Python for general scientific computing. Best of all, it can be downloaded for free in PDF format from the author/publisher's webpage (https://greenteapress.com/wp/think-python-2e/). This is a "recommended" text and is not strictly required for the course, but it provides additional descriptions, examples, and exercises to help you develop greater proficiency with Python and numerical methods. The Python packages that we will be using for the course (mostly **matplotlib** and **NumPy**) have excellent documentation and you are encouraged to use these resources regularly to get in the habit of understanding the tools you are using:

- **matplotlib [https://matplotlib.org/]** has Examples, Tutorials, and a Reference page for each package component; this page is highly searchable and often if you type **"matplotlib <name of function>"** into your favourite search engine you will get a relevant result. Try searching **"matplotlib pyplot.plot"** and visit the first page from the results for a start.
- **NumPy [https://numpy.org/]** also has Documentation with Getting Started, User's Guide, and API Reference sections. Again, this information is highly searchable and often a search of **"numpy <name of function>"** will return a relevant result.

Try **"numpy sin"**, **"numpy interpolate"**, or **"numpy linalg.solve"** for a start.

In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

- A computer with a supported operating system, as well as the latest security, and malware updates;
- A current and updated web browser;
- Webcam/Camera (built-in or external);
- Microphone and speaker (built-in or external), or headset with microphone;
- Current antivirus and/or firewall software enabled;
- Stable internet connection.

For more information please refer to the UofC ELearning online website.

7. **Examination Policy:**

The quizzes and midterm exams will be open book, open notes and you will be allowed to use any calculator including software such as Python and Excel. Internet access will be allowed, but verbal, written, or electronic communication is not allowed during the exam, unless otherwise noted in the exam instructions. If there is a conflict between the course outline exam policy and the instructions noted on the exam, the exam instructions take precedence.

Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory And Optional Course Supplemental Fees:**

There are no mandatory or optional course supplemental fees for this course.

9. **Writing Across The Curriculum Statement:**

For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

10. **Human Studies Statement:**

Students will not participate as subjects or researchers in human studies.

See also Section E.5 of the University Calendar.

11. **Reappraisal Of Grades:**

A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See Section I.3 of the University Calendar.

a. **Term Work:** The student should present their rationale a s effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work form to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections I.1 and I.2 of the University Calendar

b. **Final Exam:**The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **Other Important Information For Students:**

a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

b. **SU Wellness Services:** For more information, see their website or call 403-210-9355.

c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208. The complete University of Calgary policy on sexual violence can be viewed here.

d. **Student Ombuds Office:** A safe place for all students of the University of Calgary to discuss student related issues, interpersonal conflict, academic and non-academic concerns, and many other problems.

e. **Student Union Information:** SU contact, Email your SU Science Reps: science1@su.ucalgary.ca, science2@su.ucalgary.ca, science3@su.ucalgary.ca,

f. **Academic Accommodation Policy:**

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Accommodation-Policy.pdf

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf.

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, by filling out the Request for Academic Accommodation Form and sending it to Brandon Karchewski by email brandon.karchewski@ucalgary.ca preferably 10 business days before the due date of an assessment or scheduled absence.

g. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional Code of Conduct and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

Student Handbook on Academic Integrity
Student Academic Misconduct Policy and Procedure
Faculty of Science Academic Misconduct Process
Research Integrity Policy

Additional information is available on the Student Success Centre Academic Integrity page

h. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or non-academic misconduct, in addition to any other remedies available at law.

i. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

j. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

Calendar Description:

Numerical algorithms for estimation of model parameters. Objective functions, norms, root finding, curve fitting, least squares regression, unconstrained optimization, constrained optimization, gradient ascent/descent, Newton-Raphson. Applications to a variety of geophysical survey methods.

Learning Objectives:

By the end of this course, students should be able to:

1. ***Explain*** and ***implement*** numerical solution algorithms to some of the most fundamental problems in applied mathematics (root finding, solution of linear systems, parameter estimation using least squares regression), applied within a geophysics context.
2. ***Perform*** error analyses of approximate numerical solutions and discuss whether the solutions are

acceptable.
3. ***Explain*** the advantages and limitations of the numerical techniques examined in the course.
4. ***Distinguish*** between and select the most applicable of available numerical techniques for an analysis task in geophysics.
5. ***Use*** software packages (spreadsheet tools such as MS Excel and programming languages such as Python 3) to compute numerical solutions.
6. ***Communicate*** the results of numerical analysis to peers in the scientific community and ***critically evaluate*** the work of peers.

Electronically Approved - Jan 09 2024 11:07

Department Approval