ERTH 250 SCIENTIFIC PROGRAMMING [3 CR]

M+W: 12:30–1:20 POST 733, R: 1:30–4:20 POST 703 Fall 2024

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Course Introduction: The computer is an indispensable tool in engineering and the natural sciences, i.e. the "STEM" fields of study. Having computer programming skills will allow STEM students to best leverage computers in their work. While computer programming can be taught using a variety of languages, such as Java and C++, practicing scientists and engineers also need to visualize program output and analyze data. ERTH250 introduces students to this material in a one-semester introductory course using the MATLAB® and Python. From Wikipedia, "***MATLAB*** *(**mat**rix **lab**oratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran*". It comes with a vast library of numerical and graphical functions and is therefore ideally suited for solving a broad range of technical problems. It is available for all major platforms (Windows, Macintosh, Linux, Unix) and a UHM Site License is available to all students. From Wikipedia, "***Python*** *is a high-level, interpreted, general-purpose programming language [that] emphasizes code readability. Python is dynamically-typed and garbage-collected. It supports multiple programming paradigms, including structured, object-oriented and functional programming."* It also has a comprehensive standard library of functions and is free to use, with a large and active user and developer community.

Course Goals: Enable students to solve practical problems using the MATLAB and Python programming language(s).

- Learn the concepts of programming, i.e., variables, control flow, input/output, functions, and more.
- Gain experience in developing solutions to multi-step problems.
- Design solutions while utilizing your math and physics knowledge.
- Practice translating such solutions into working code.
- Experience how to test your code and to identify and correct bugs.
- Appreciate the importance of documentation and clarity of code comments.
- Work collaboratively in a coding environment.

Course Format: Two 50-minute lectures and one 3-hour lab weekly. Standard lecturing will be interspersed with hands-on demonstrations and in-class exercises. Important material will be introduced and discussed in the lectures and the labs will require you to utilize this material in practice. During labs the instructor will clarify common misconceptions and guide students in the most productive direction. Lab submissions are due after one week, before the beginning of the following lab. After initial submission, students will work together in assigned pairs on "code review" to improve labs before they are graded (see below). Lab topics will range from the mundane to the crazy, including basic data analysis, simulating the launching of projectiles, counting money, reuniting South America with Africa, analyzing letter frequencies in languages, exploring games of chance, and much more.

Course Prerequisites: MATH 241 (or concurrent) or departmental approval. No Earth science background is needed.

We divide the course into four main sections:

I. **Introduction** [1 week]: Purpose and goals, organization and course rules, introduce MATLAB.
II. **Using MATLAB** [~4 weeks]: Evaluate expressions, read data, plotting, layouts and saving figures,

arrays and indexing.

III. **Programming in MATLAB** [~7 weeks]: Design, flowcharts, pseudo code, and documentation, data types, relational operators, control flow, loops, procedural programming, debugging. At the conclusion of this section will be exam 1 (~end of October).

IV. **Programming in Python** [~4 weeks]: Design, flowcharts, pseudo code, and documentation, data types, relational operators, control flow, loops, procedural programming, debugging. At the conclusion of this section will be exam 2 (during final examanation).

Following the introductory section I, we will spend a few weeks using MATLAB as a tool to calculate, visualize, and analyze data (section II), and then the bulk of the class will be devoted to learning programming (section III). The final month will be devoted to learning programming in Python.

Exams: There will be two exams on the course material. The first will be at the end of October (I will provide the exact date by the end of September) and the second during the final exam time (it will *not* be cumulative). The first exam will be on the MATLAB material and the second on the Python material. You will not need a computer or calculator for either exam, just a pen. I will provide a review sheet for each exam that outlines the material that you will need to know, largely broken down by the lecture in which that material was introduced.

Code Review: A student assistant will be leading the code review process. Labs are due (submitted to your drop box on Laulima) by the beginning of the next lab session (one week after the lab was assigned). At that point you will be randomly assigned a partner (double blind/anonymous) that will review your code and provide feedback and suggested edits. You will then receive the reviewed code and can revise your original submission before submitting the final version (that will be graded) at the beginning of the following lab section (two weeks after the lab was assigned). For example, the first lab will be on Thursday, September 5. It will be due by 1:30pm HST on Thursday, September 12. By 1:30pm HST on Friday, September 13, the student assistant will have assigned partners for code review and transferred the files via Laulima. By 12:30pm HST on Monday, September 16 you will submit the review of your partner's code to Laulima. The student assistant will transfer your reviewed code back to you by Tuesday, September 17 at 5pm HST. You can then update your code based on the review from your partner and submit for final grading by 1:30pm HST on Thursday, September 19. I (Sloan) will grade this final version. Instructions for file formatting and the format of the review will be provided during the first lab session.

Text: Amos Gilat, MATLAB– An Introduction with Applications, John Wiley. Reading the text is not required but it is available to supplement lecture and lab-based learning.

ERTH Student Learning Objectives (SLOs): The Earth Sciences department has defined 5 learning objectives for the undergraduate degree program related to Relevance of Earth Sciences, Technical knowledge, Scientific method, Oral and written skills, and Evaluating Phenomena. This course incorporates content relevant to 3 of those:

- SLO2: Students can apply technical knowledge of relevant computer applications, laboratory methods, field methods, and the supporting disciplines (math, physics, chemistry, biology) to solve real-world problems in the Earth Sciences.
- SLO3: Students use the scientific method to define, critically analyze, and solve a problem in earth science.
- SLO4: Students can reconstruct, clearly and ethically, geological knowledge in both oral presentations and written reports.

While SL02 enters particularly strongly via the development of programming and applying math and physics knowledge, SLO3 enters in how we break down a problem into multiple steps and test how each part works. SL04 mostly enters via the written lab reports and potentially the final project report. Students will reach the SLOs by doing labs and may be tested for factual knowledge at a mid-semester and final

exam.

Assessment and Grading: The labs are the most important aspect of the course given that programming hands on and experience-based. Labs must be submitted via Laulima by the due date in order for you to get full credit, unless you have made arrangements with me to hand it in late. Late reports will receive 50% credit only. Final grade will be a weighted average of grades for labs (50%), code review for lab (15%), exam 1 (20%; Matlab material), and exam 2 (15%; Python material). If you stay on top of your labs (coming to lab, working collaboratively, utilizing code review, coming to office hours when you need additional help) you should be able to get close to the full 50%. Completing the code review will be 15% of your grade—I expect everyone to get this 15%, all you have to do is participate in code review. Exam 1 (20%) is worth more than exam 2 (15%) because it covers a larger proportion of the course material.

Class Format: Each week has two 50-minute lectures and one 3-hour lab. You are encouraged to actively ask questions in class, particularly if you do not understand the material being discussed. Most lectures involve examples on the computer, interspersed with standard lecturing. Most of the important material will be introduced and discussed in the lectures, although each weekly lab starts with an overview of the current lab exercise and the relevant background material. Students then work on the lab in small groups until time is up, asking questions of the instructor along the way. The instructor will clarify common misconceptions and help to lead groups in the most productive direction. The lab submission is due one week later.

Disability Access: If you have a disability and related access needs I will make every effort to assist and support you. For confidential services students are encouraged to contact the Office for Students with Disabilities (known as "Kokua") located on the ground floor (Room 013) of the Queen Lili'uokalani Center for Student Services:
KOKUA Program; 2600 Campus Road; Honolulu, Hawai'i 96822 Voice: 956-7511; Email: kokua@hawaii.edu ; URL: http://www.hawaii.edu/kokua

Discrimination: The University of Hawai'i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know is experiencing any of these, the University has staff and resources on your campus to support and assist you. Staff can also direct you to resources that are in the community. Here are some of your options:
As members of the University faculty, your instructors are required to immediately report any incident of potential sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and your instructors cannot guarantee confidentiality, you will still have options about how your case will be handled. Our goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need.
If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, use the **confidential resources available here**: http://www.manoa.hawaii.edu/titleix/resources.html - confidential
If you wish to directly REPORT an incident of sex discrimination or gender-based violence including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence or stalking as well as receive information and support, contact: Dee Uwono Title IX Coordinator (808) 956-2299 t9uhm@hawaii.edu.