ASTR260L: Computational Physics & Astronomy Lab

Spring 2017: January 9–May 12

M 3:00 PM–5:50 PM, Room: STB 206

Version 3: April 10, 2017 (subject to change)

Instructor:	Kathy Cooksey, Ph.D., STB 219; `kcooksey@hawaii.edu`; 808-932-7195
Office Hours:	W 9–9:50 PM & 2–3 PM, F 11–11:50 AM, and by appointment
Websites:	Laulima ASTR-260L-001 (HIL.13628.SP17)
Textbook:	*Computational Physics* (revised and expanded 2013) by Mark Newman

Course Description:

The course catalog description: "Will offer an introduction to `UNIX` command language and programming skills relevant to astronomy. Emphasis on writing algorithms and code programming in `Python`, `C++`, or `Fortran`. Some elements of `IDL` and `IRAF` are covered. Problems will come from physics and astrophysics that will be solved using numerical methods and mathematical algorithms presented in the ASTR/PHYS260 lecture. Topics covered are integration methods, interpolation, error estimation, eigenvalues and eigenvectors, linear and non-linear equations, Fourier methods, random numbers and Monte-Carlo methods."

Pre-requisites: PHYS171 or PHYS173; ASTR/PHYS260 (may be taken concurrently)

Learning Objectives:

- Improve programming skills in the adopted language, specifically for scientific computing, which requires attention to testing and visualizing results. The ability to test code enables one to reliably adopt "blackbox" algorithms for any given application.
- Understand the physics and astronomy applications of the various numerical techniques.
- Learn various numerical methods for:
  - integrating and differentiating functions,
  - solving linear and nonlinear equations,
  - solving first-order differential equations, and
  - applying Monte-Carlo techniques.
- Improve knowledge of `UNIX` operating system.
- Learn about and test for numerical accuracy and speed.
- Understand how to apply familiarity with one programming language to another language.

Email, Textbook, Website, and Computer(s):

- UHH considers email and Laulima an official form of communication; students are responsible for receiving and returning information in a timely manner.
- The student must ensure that the instructor has her/his correct email address.
- The required textbook is *Computational Physics* (revised and expanded 2013) by Mark Newman.
- The Laulima course website is listed under ASTR-260L-001 (HIL.13628.SP17). This site will be the hub for all course information.
- Each students will be assigned a STB 206 computer with a private account. The lab computers can be accessed via `SSH`.
- Any submitted code must run on the assigned computer, though code development can be on the student's private computer. Various programs and packages are available or can be installed.
- Students will also have keycard access to STB 2nd floor doors and STB 206 so they may use the lab computers at any time.

Class Rules:

1. Students are responsible for their own learning, which includes preparing for class, submitting work, asking questions, and seeking additional help.
2. Students should be respectful and supportive of their peers' learning, which means helping each other with difficult concepts but not just giving the answer.
3. Students should convey (either in person, by email, through an intermediary, or somehow) to the professor questions, comments, and concerns about the course.
4. The professor should be receptive to and respectful of the students' needs and interests and should generally follow the class rules as detailed for the students.
5. Group work is encouraged in class and for homework assignments. However, all submitted work must be the original work of the student with reference to any homework partners.
6. All references (e.g., websites, books other than the official course textbook, etc.) used to complete assignments must be cited, including numbers, techniques, facts, etc.
7. Sign in each class on the attendance sheet.

Good-to-Know about the Professor:

- She enjoys teaching and wants to be better at it, and she really cares about helping students be better. These aspects combined mean she is on the students' side; trust in that and knowledge that she is receptive to feedback will smooth over rough patches.
- She chooses teaching techniques based on physics-education research to support student learning as best as possible. This means she has one or more reasons for nearly every component of and action in a course. She'll gladly motivate these choices whenever necessary or asked.
- Her primary goal is to help students improve *how* they learn with the logic that if students learn how to learn, they can master any content. The related goal is to focus on transferrable skills so that time and effort spent for the class yield benefits beyond the course and semester.
- Generally, she does not answer questions directly. A student making connections and constructing a solution her- or himself will ingrain the answer more effectively, and the professor facilitates the process by asking leading questions. Since the motivation is to help the students, they should embrace and engage with this process. (It is also a transferrable skill to discuss ideas and answer questions on the fly.)
- She designs quizzes and exams so that no one gets 100% and no one gets 0% because either score would not be useful in assessing what the students understand and how to help. The rule-of-thumb is to score above the median (see Grading below). She has no interest in failing students who make good-faith effort in the class (e.g., good attendance, submit completed work, ask questions in and out of class).
- She thinks no single resource is comprehensive, so the expectation is that the student will have to work with the professor, her materials, the textbook, and the wealth of material available on the internet.
- The expectation is that a course requires 2–3 hr outside-of-class time per credit per week. Hence a 15-cr semester equals 30–45 hr per week (i.e., a full-time job).
- She generally responds to email 24-to-48 hours after receipt. If the matter is urgent, the student should call (office voicemail is automatically emailed) or stop by her office (her generally weekly schedule is on her homepage: `http://www2.hawaii.edu/~kcooksey`).
- She can best support the following programming languages (in decreasing order of proficiency): `IDL`, `Python`, `Java`, and `C++`, though she can generally hack code.

General Course Outline (subject to change)

Students are expected to read the textbook chapter or section(s) before class. The labs will rely on students having given a good faith effort to understanding the material. It is assumed that the students will read the brief introduction to each chapter, no matter the number of sections actually assigned.

Work completed in lab is to be submitted at the end of the lab period. This will be a hardcopy or work uploaded to Laulima:Drop Box, in a folder/subfolder of the format `Lab[#]/InLab` (e.g., `Lab4/InLab`, no number sign and no spaces). Files are time-stamped and must not be altered after lab. The in-lab work will be graded for progress or correctness, as appropriate.

Assignments are to be completed after lab and due at the start of the next lab period. (Thus, if there is no lab due to a holiday, there are two weeks to complete the assignment.) Not every lab will require an assignment. Assignments will typically be a code, which is to be uploaded to Laulima:Drop Box, in a folder/subfolder of the format `Lab[#]/PostLab` (e.g., `Lab4/PostLab`, no number sign and no spaces) and with the specified name for the source code and sensibly named related files (e.g., `README`, figures). Some assignments may be reports that should be uploaded to the same subfolder as PDFs. Assignments will be graded for correctness.

Date	**Topic**
M 9 Jan	Lab #1. Intro to `UNIX`, `Emacs`, & `Python` *(Post-Lab due M Jan 23)* (Review `UNIX`, `Emacs`, & `IDL` Tutorial (Laulima:Resources:Useful Websites; especially §1.4.2; ignore `IDL`) and Ch 2 from *Computational Physics* textbook)
M 16 Jan	MLK Day (no class)
M 23 Jan	Lab #2. Programming in `Python` (Ch 2–4) *(Post-Lab due M Jan 30)*
M 30 Jan	Lab #3. Numerical Differentiation (§5.10)
M 6 Feb	Lab #4. Interpolation (§5.11) *(Post-Lab due M Feb 13)*
M 13 Feb	Lab #5. Numerical Integration I (§§5.1–5.7)
M 20 Feb	President's Day (no class)
M 27 Feb	Lab #6. Numerical Integration II (§§5.8–5.9) *Laulima survey: Mid-course evaluation assigned (due M 6 Mar)*
M 6 Mar	Lab #7. Linear Equations (§§6.1–6.2) *(Post-Lab due M Mar 20)* *Laulima survey: Mid-course evaluation due*
M 13 Mar	Lab #8. Root-Finding (§6.3)
M 20 Mar	Lab #9. Extrema-Finding (§6.4)
27–31 Mar	Spring recess (no class)
M 3 Apr	Lab #10. First-order Differential Equations (§8.1) *(Post-Lab due M Apr 10)*
M 10 Apr	Lab #11. Second-order Differential Equations (§§8.2–8.3) *(Post-Lab due M Apr 17)*
M 17 Apr	Lab #12. Monte-Carlo Integration (§§10.1–10.2)
M 24 Apr	Lab #13. Monte-Carlo Simulation (§10.3) *(Post-Lab due M May 1)*
M 1 May	Final Exam (timed coding test)
8–13 May	Final Exam Week (no class)

Grading:

- The grade depends on the following items: in-lab work (50%); post-lab assignments (30%); and the final exam (20%). The lowest in-lab work and post-lab assignment grades will be dropped.
  - If a student notices an inconsistency in the instructor's grading, s/he should ask; it might be a mistake or it might be a subtle point. Students are encouraged to ask questions about grading.
- There will be no make-up work other than the final exam.
  - If a student were excused, the graded work will not be included in her/his final grade.
    - If a student must miss a class for a reasonable reason, s/he must email the professor before the start of class time.
    - If a student were unable to email in advance due to extreme circumstances, s/he should contact the professor as soon as possible. Such instances will be judged on a case-by-case basis.
      - In such (and similar) situations, the student is strongly encouraged to contact Student Services (info below). Student Services are liaisons between students and instructors, when Life adversely impacts Academics. If Student Services intervenes on a student's behalf, the instructor will work to accommodate any missed content and points.
    - If a student were excused from all points in a given category, the percentage of the other categories will be increased to fill the void.
- Post-lab assignments are never excused since their due dates are known in advance (namely, the start of the next lab period). It is the student's responsibility to turn in the assignment somehow, either by giving it to another student to submit or by scanning and emailing it to the professor.
- Late post-lab assignments are accepted within 24 hours of the deadline for 75% credit.
  - In-lab work is due at the end of the lab period. It only counts if the student attended the lab and submitted the material correctly (hardcopy and/or via Laulima:Drop Box, which is time-stamped).
- Cheating is not tolerated. Any question of cheating will be tested with an oral exam, to see whether the student(s) involved understand the material. Cheating will result in a zero for the item in question and a report to the University. It may result in immediate failure of the course.
- The final letter grade will be given based on the class statistics (e.g., the 25^{th}, 50^{th}/median, 75^{th} percentiles). The goal is to score higher than the median on all graded work. The expectation is that final grades higher than the median will pass with at least a C but that the 25^{th} to 50^{th} percentiles may earn something in the C range.

Code Rubric
Programs will be graded using the decision tree below:

1. Does the program run?
   If yes, 3 pt. If no, skip to #6.
2. Does the program run using the program file and call(s) specified in the problem (typically, `answer()`)?
   If yes, 1 pt. If no, skip to #6.
3. Does the code follow the problem specifications regarding what to do (e.g., numerical method, printed output, plots)?
   If yes, 1–2 pt. If no, skip to #6.
4. Are the numerical answers accurate?
   If yes, 1–5 pt.
5. Is there evidence reasonable testing was done?
   If yes, 1–2 pt.
6. Is the code readable? (Example assessments below.)
   If yes, 1–2 pt.
   - Are variables reasonably named?
   - Are user-defined functions used appropriately?
   - Are units explained in comments?
   - Are external resources referenced for e.g., "blackbox" algorithms or pieces of code written by another?
   - Is any output formatted with a label and/or unit?
7. Does the source code provide information on who wrote it, what it generally does, and what each function does?
   If yes, 1 pt.
8. Was there sufficient content in the solutions (as applicable) provided (e.g., deriving equations analytically; assessing what the problem means in the context of physics and astronomy, including computational; etc)?
   If yes, 1–5 pt.
9. Is there a README or other instructions on how to run the program(s)?
   If yes, 1 pt.

There will be 22 pt total when there is an expected solution (#8) and 17 pt otherwise. Thus a problem with an e.g., derivation is worth 30% more than a coding-only problem. A code that does not run could receive a maximum of 9/22 (41%) or 4/17 (23.5%).

Campus-wide Information

Disability Support: Any student with a documented disability who would like to request accommodation should contact the Disability Services Office—Student Services Center, E215; 932-7623 (V), 932-7002 (TTY), `uds@hawaii.edu`—as early in the semester as possible.

Advising: Advising is a very important resource designed to help students complete the requirements of the University and their individual majors. Students should consult with their advisor at least once a semester to decide on courses, check progress towards graduation, and discuss career options and other educational opportunities provided by UH Hilo. Advising is a shared responsibility, but students have final responsibility for meeting degree requirements.

Kilohana Academic Success Center: The KASC provides academic support opportunities for all UH Hilo students that foster their development into independent, self-motivated learners. Students who visit Kilohana have access to subject-specific and academic skills tutoring from UHH students selected for their academic achievement and dedication to helping others succeed. Kilohana is located on the lower level of the Mookini Library and on the web at `http://hilo.hawaii.edu/kilohana/`.

Human Rights: The University of Hawai'i at Hilo prohibits discrimination in its education programs based on race, national origin, color, creed, religion, sex, age, disability, veteran status, sexual orientation, gender identity or associational preference. If at any time during class you feel uncomfortable about what is being talked about, or feel that your human rights have been violated, please feel free to leave the room. However, the professor asks that you confer with her as soon as possible about what happened so that appropriate action can be taken if necessary to avoid future problems. If you are uncomfortable speaking with the professor about your concern, please contact Kalei Rapoza (`kaleihii@hawaii.edu`), Interim EEO/AA Director, at 932-7626.

UH Hilo Title IX Policy: The University of Hawaii 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:

> If you wish to remain anonymous, speak with someone confidentially, or would like to receive information and support in a confidential setting, contact: • UH Hilo Counseling Services: SSC, room E-203, 932-7465; • UH Hilo Medical Services: Campus Center, room 212, 932-7369; and/or • Hawai'i Island YWCA, 935-0677.
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> If you wish to 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: • Libby Bailey, Title IX Coordinator, 932-7818, `libby.bailey@hawaii.edu`; • Jennifer Stotter, Director of the Office of Equal Opportunity & Deputy Title IX Coordinator, 932-7641, `jstotter@hawaii.edu`; and/or • Kalei Rapoza, Interim Director of Human Resources, 932-7626, `kaleihii@hawaii.edu`.
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> [†]Please note that you do not have to file a report with the University to receive institutional support or assistance.

As a member of the University faculty, the professor is required to immediately report any incidence of sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and professor cannot guarantee confidentiality, the student will still have options about how the case will be handled. The goal is to make sure the student is aware of the range of options available and has access to the necessary resources and support. For more information regarding sex discrimination and gender-based violence, the University's Title IX resources and the University's Policy, Interim EP 1.204, go to: `http://www.hawaii.edu/titleix`.

Student Conduct: Students are expected to follow the University of Hawai'i at Hilo Student Code of Conduct available at the following URL: `http://www.uhh.hawaii.edu/catalog/student-conduct-code.html`.