ASTR260: Computational Physics & Astronomy
Spring 2017: January 9–May 12
MWF 1:00 PM–1:50 PM, Room: STB 206

Version 2: March 11, 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-260-001 (HIL.13462.SP17)
Textbook:	*Computational Physics* (revised and expanded 2013) by Mark Newman

Course Description:

The course catalog description: "Computational techniques in physics and astronomy, with an emphasis on fundamental algorithms and development of code in high-level languages. Topics include least squares, interpolation, random number generators and numerical integration of differential equations."
Pre-requisites: PHYS171 or PHYS173; and CS150

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-260-001 (HIL.13462.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 "lectures" 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.

Homework (in *italics*) are due every two weeks, by class time. They are to be uploaded to Laulima:Drop Box, in a folder of the format `HW[#]` (e.g., `HW3`, no number sign and no spaces) and with programs of the specified name(s) and sensibly named related files (e.g., `README`, figures).

Quizzes are given after the homework covering the same topic have been returned (to give a chance for review), but all previous material is fair game. This pattern is designed so that students have a chance to: (1) learn the material via lecture and assignments; (2) practice the content via assignments; and (3) receive feedback via graded work and/or posted solutions. Thus there is a lag between material being the focus of lecture and when the material will be on a quiz.

Date	**Topic**	**Activity**
M 9 Jan	L1. ASTR260 Overview (Ch 1)	Pre-quiz
W 11 Jan	L2. Programming Review I (Ch 2)	
	Also review `UNIX`, `Emacs`, & `IDL` Tutorial (Laulima:Resources:Useful Websites; especially §1.4.2; ignore `IDL`)	
F 13 Jan	L3. Programming Review II	
M 16 Jan	MLK Day (no class)	
W 18 Jan	L4. Programming Review III (§§3.1–3.3)	
F 20 Jan	L5. Programming Review IV	
M 23 Jan	L6. Accuracy & Speed I (Ch 4)	
W 25 Jan	L7. Accuracy & Speed II	*HW #1: "Programming Fundamentals" assigned (due W 8 Feb)*
F 27 Jan	L8. Numerical Differentiation I (§5.10)	
M 30 Jan	L9. Numerical Differentiation II	
W 1 Feb	L10. Interpolation (§5.11)	
F 3 Feb	L11. Numerical Integration I (§§5.1–5.3)	
M 6 Feb		Pre-HW #1 Q&A
W 8 Feb	L12. Numerical Integration II (§§5.4–5.5)	*HW #2: "Numerical Diff. & Interpolation" assigned (due W 22 Feb)*
F 10 Feb	L13. Numerical Integration III (§§5.6–5.7)	
M 13 Feb		Pre-Quiz #1 Q&A
W 15 Feb		Quiz #1 [HW #1]
F 17 Feb		Pre-HW #2 Q&A
M 20 Feb	President's Day (no class)	
W 22 Feb	L14. Numerical Integration IV (§§5.8–5.9)	*HW #3: "Numerical Integration" assigned (due W 8 Mar)*
F 24 Feb	L15. Numerical Integration V	*Laulima survey: Mid-course evaluation (due F 3 Mar)*
M 27 Feb	L16. Linear Equations I (§6.1)	
W 1 Mar	L17. Linear Equations II	
F 3 Mar	L18. Linear Equations III	
M 6 Mar	L19. Linear Equations IV (§6.2)	
W 8 Mar	L20. Linear Equations V	*HW #4: "Linear Equations" assigned (due W 22 Mar)*
F 10 Mar	L21. Linear Equations VI	
M 13 Mar	L22. Nonlinear Equations I (§6.3)	
W 15 Mar		Quiz #2 [HW #2 & 3]
F 17 Mar	L23. Nonlinear Equations II	
M 20 Mar	L24. Maxima & Minima of Functions I (§6.4)	
W 22 Mar	L25. Maxima & Minima of Functions II	*HW #5: "Root- & Extrema-Finding" assigned (due W 12 Apr)*
F 24 Mar	L26. Eigenvalues & Eigenvectors (§6.2)	
27–31 Mar	Spring recess (no class)	
M 3 Apr	L27. First-order Differential Eqns. I (§8.1)	
W 5 Apr	L28. First-order Differential Eqns. II	
F 7 Apr	L29. First-order Differential Eqns. III (§8.2)	
M 10 Apr	L30. Second-order Differential Eqns. I (§8.3)	
W 12 Apr	L31. Second-order Differential Eqns. II	*HW #6: "Differential Equations" assigned (due W 26 Apr)*
F 14 Apr	Good Friday (no class)	
M 17 Apr	L32. Monte-Carlo Integration (§§10.1–10.2)	
W 19 Apr	L33. Monte-Carlo Simulation I (§10.3)	
F 21 Apr	L34. Monte-Carlo Simulation II	
M 24 Apr	L35. Deciphering Another Language I	
	Review `IDL` section of `UNIX`, `Emacs`, & `IDL` Tutorial (Laulima:Resources:Useful Websites)	
W 26 Apr		Quiz #3 [HW #4 & 5]
F 28 Apr	L36. Deciphering Another Language II	
M 1 May	L37. Course synthesis	
W 3 May		Course evaluations & post-quiz
M 8 May	Final Exam	11:50 AM–1:50 PM

Grading:

- The grade depends on the following items: homework assignments (40%); completing pre- and post-quizzes (5%), quizzes (35%); and the final exam (20%). The lowest homework grade 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.
- Homework assignments are never excused since their due dates are known in advance. It is the student's responsibility to turn in the homework somehow, either by giving it to another student to submit or by scanning and emailing it to the professor.
- Late homework is accepted within 24 hours of the deadline for 75% credit.
- 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?

   You may always write any functions you find necessary for functionality and readability, even if they are not required.
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`.