Computational Physics – Physics 332
Westminster College

Pertinent Information

Instructor: Douglas Armstead
Office: 124 Hoyt (724) 946-7201
Email: armstedn@westminster.edu
Course website: www.westminster.edu/staff/armstedn/S12/ComputationalPhysics.html
Class meets: MWF 4:20-5:20 in Electronics Lab.
Texts:
Computational Physics by Giordano and Nakanishi published by Pearson.
Mathematical Methods in the Physical Sciences by Boas published by Wiley.
Prerequisites: Physics 331.

The Point of this Class [1]

This course is the continuation of Computational Physics 1. In the first semester of computational the approach was a mixure of analytical and numerical with an emphasis on the analytical. When they are tractable analytical methods are often illuminating. This is not always the case, and at these times a numerical approach can be very helpful.

This course will also have a mixture of analytical and numerical techniques but the stress will be on using a numerical approach to analyzing physical processes. It will emphasis problem solving and build upon the analytical skills developed in Computational Physics 1. The central goal of the course is to use computers to address physical questions. As such computer science will play a supporting role, but only to the extent that it helps us understand physics.

By the end of this course you will be expected to be proficient at

- translating analytical expressions into expressions that can be calculated by a computer,
- extracting meaningful results from your computer calculations by
  - making the computer sift through results to find extrema
  - using graphical techniques to represent your data

[1] If you are looking for the outcomes of this course, they are here. This course's effectiveness will be assessed by monitoring the quality of the student's work on the graded elements of this course. See Graded Elements section for their descriptions.

- processing the data with fourier techniques.

- finding numerical solutions to physically relevant ordinary differential equations (ODEs) and partial differential equations (PDEs), and simulating random type processes.
- express the results of your analysis clearly.

Expectations

What you should expect from me:

- Explanations of physical concepts that include concrete examples and, where reasonable, demonstrations.
- In-class examples that help you to develop the level of reasoning that is necessary to do the problems you will encounter in the homework and on exams.
- Careful and respectful consideration of your questions.
- An open door policy–if my office door is open you should feel free to come in and talk about physics. This is in addition to my regularly scheduled office hours listed above.

What I expect of you:

- Your presence in class, both physical and mental, for the entire class period.
- To prepare for class. This includes doing the reading at a level that you arrive with questions in hand about the material.
- When you have a question, ask it. Your fellow classmates will thank you–if you are unclear on something, chances are the person next to you is, too.
- Submit work for grading that is your own. If you copy from another student or source and submit it for a grade, then you risk receiving an F in the course.

Grades

The final score for the class is found in the following way:

$$score = \frac{H + E + P}{3} \tag{1}$$

where H =homework average, E = midterm exam, and P =final project.

Graded Elements

There are a number of measures against which you can check your progress in the course. These include the homework assignments, the midterm exam, and the final project.

Homework: The point of the homework is to learn how apply these techniques and where they tend to be useful. It is important to remember that as with any computation the results are not inherently obvious. It is important to give context for your results (e.g., what approximations did you make, what numerical technique did you use, how do your results come out of your raw data) represent those results in a clear way (e.g., clearly labeled graphs, organized tables) and where appropriate comment on the bigger implications of the results. A solution like this will be some what like a lab report in feel. In addition to the solution you should submit your working code that you used to construct your results (both source code and executable file) to the R: drive (in the work directory).

Exam: The midterm exam will have an in-class format. This exam will be primarily concerned with the techniques we discuss out of Boas (solving differential equations, vector derivatives, and Fourier analysis). It will also touch on the methods from the numerical part of the course.

Make-up exams will only be administered for "Excused Absences" (see pages 70-71 of Undergraduate Catalog for details). Supporting documentation to excuse your absence will be required.

Project: One reason to do computational physics is the accessibility of interesting questions. This is an extension of the observation that all of the interesting questions in quantum mechanics are done using perturbation theory. In the final project you will use the computational methods you have learned in this course and apply them to an interesting question of your own choosing. These may come from the topics discussed in chapters of *Computational Physics* that we will not formally cover (Chapters 4, 8-12) or a question you devise on your own. Some examples from previous years are available upon request.

You are expected to apply to present your project results at the Undergraduate Research and Arts Celebration (URAC) on Wednesday April 25th. This can be in the form of a poster or a talk. Applications are due in March and if you choose to give a poster, it must be submitted to AV for printing by Wednesday April 11th. Keep in mind that the audience for these talks and posters is the general college community.

Notice in the schedule that there is one week devoted to the project. Completing this project will certainly take more than 1 week and will require that you do significant work on this project outside of class.

In addition to URAC you will be presenting the results of your project to your peers during the final exam period for the class. A written lab report style document discussing the motivation, method and results for your project will also be due on that day.

The score is mapped into a grade roughly as:

Final %	Grade
90-91,92-100	A- to A
80-81,82-86,87-89	B- to B+
70-71,72-76,77-79	C- to C+ etc.

Improvement and class participation may be used raise a border line grade.

Academic Integrity

You are expected to observe the College's statements and procedures on Academic Integrity in your Undergraduate Catalog, near pages 72-76. Ask me if you have any uncertainty about what is proper collaboration and what is not.

Class Schedule

All dates are tentative.

Week	Chapter(s)	Topic
1	Boas 8.5& Giordano 3.1	2^{nd} order ODEs.
2	Boas 7	Fourier Series
3	Giordano 3.2-3.3	Oscillatory Motion and Chaos
		Project proprosal due Friday Jan. 27.
4	Boas 7	Fourier Transform
5	Giordano 3.8	Power spectrum and Fast Fourier Transform.
6	Boas 6	Div, Grad, Curl
7	Boas 13	PDEs
8	Giordano 5.1-5.2	Potentials and Fields–PDEs and relaxation solutions (E-fields).
9	Giordano 6.1	Waves–Solving the wave equation.
		Midterm exam
10	Giordano 6.2-6.3	Frequency spectrum and dispersion of string waves.
11	Giordano 6.4	Waves with spectral approach.
12	Project	
13	Giordano 7.1, 7.4	Random Systems–Random walks.
		W April 25 is URAC, your presentation day
14	Giordano 7.5-7.6	Diffusion, entropy, arrow of time, cluster growth.

Final Exam is Monday May 7 at 6:30-9pm.