Computational Physics – Physics 332
Westminster College

## 1 Pertinent Information

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Course website: www.westminster.edu/staff/armstedn/ComputationalPhysics.html
Class meets: Thursday 2-5 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.

## 2 The Point of this Class [1]

This course is the complement to Computational Physics 1. In the first semester of computational the approach was 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 stress 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.

The areas in which you will gain proficiency include translating analytical expressions into expressions that can be calculated by a computer, representing the data from numerical calculations in meaningful ways, finding numerical solutions to physically relevant ordinary differential equations (ODEs) and partial differential equations (PDEs), and simulating random type processes.

[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.

# 3 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.

# 4 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.

## 4.1 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, and the final project.

The point of the homework is to solve problems. Lots of problems. This makes you proficient at using the techniques and also shows some of the situations in which these techniques are useful.

The midterm exam will have an in-class format. It will be paper and pencil and will help keep you honest. (Many feel a strong impulse to approach computation as a trial and error affair. This will not be enough in this 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.

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.

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.

### 4.2 Academic Integrity

You are expected to observe the College's statements and procedures on Academic Integrity in the 2009-2010 Undergraduate Catalog, pages 72-76. Ask the instructor if you have any uncertainty about what is proper collaboration and what is not.

## 5 Class Schedule

All dates are tentative.

| Week | Chapter(s) | Topic |
|---|---|---|
| 1 | Giordano 1 | Radioactive Decay–$1^{st}$ order 1-Dim ODEs, Computer programming, Representing data |
| 2 | Giordano 2.1 | Projectile Motion–$2^{nd}$ order ODEs. |
| 3 | Giordano 2.2-2.4 | Cannons and baseballs, improving realism. |
| 4 | Giordano 3.1-3.3 | Oscillatory Motion and Chaos–SHO, DHO, Limits of Euler, and a touch of Chaos. |
| 5 | Giordano 3.4-3.5 | Period doubling route to Chaos. |
| 6 | Giordano 3.8 | Fourier analysis and power spectra. |
| 7 | Giordano 5.1-5.2 | Potentials and Fields–PDEs and relaxation solutions (E-fields). |
| 8 | Giordano 5.3-5.4 | PDEs and numerical integration (B-fields). |
| 9 | Giordano 6.1 | Waves–Solving the wave equation. |
| 10 | Giordano 6.2-6.3 | Frequency spectrum and dispersion of string waves. |
| 11 | Giordano 6.4 | Waves with spectral approach. |
| 12 | Giordano 7.1-7.3 | Random Systems–Random walks. |
| 13 | Giordano 7.4-7.5 | Diffusion, entropy, arrow of time. function, series of |
| 14 | Project | |

**Project presentation during final exam period.**