PHYS-4007/5007: Computational Physics
Syllabus — Fall 2011

Lecturer (E-mail):	Dr. Donald Luttermoser (lutter@etsu.edu)
Office (Phone):	280 Brown Hall (439-7064)
Course ID:	PHYS-4007 (undergrad-level), PHYS-5007 (grad-level)
Credit Hours:	4
Prerequisites:	PHYS-2110/20 or MATH-3200
Lecture Loc./Times:	Brown Hall 264 / M W F 2:45 p.m. – 3:40 p.m. T 3:45 p.m. – 4:40 p.m.
Office Hours:	W F: 4:00 p.m. – 5:00 p.m.
Course Web Page:	http://www.etsu.edu/physics/lutter/courses/phys4007/index.htm
Textbooks:	(1) *Computational Physics: Problem Solving with Computers* (2007) Landau, Páez, & Bordeianu (2) *Guide to LaTeX, 4th Ed.* (2003) by Kopka & Daly (3 - Optional) *Practical IDL Programming* (2002) by Gumley (This IDL book is strongly recommended.)

Course Outline

Week	Topics	Readings
Aug 29	Choosing Hardware and an Operating Systems	(1) Chaps 1, 13
Sep 5	How to Select a Programming Language (**No class on 9/5**)	(1) Chap 2
	The Art of Graphics Programming	(1) Chap 2
Sep 12	Preparing Scientific Manuscripts: LaTeX	(2) Chaps 1–4, 6
Sep 19	Error Analysis and Uncertainties	(1) Chap 3
Sep 26	Methods of Data Fitting	(1) Chap 9
Oct 3	Methods of Differentiation and Integration (**No class on 10/3**)	(1) Chaps 5, 6
Oct 7	**Take-Home Midterm Exam due**	
Oct 10	Matrices and Systems of Linear Equations	(1) Chap 8
Oct 17	Matrices (cont.) (**No classes on 10/17,18**)	(1) Chap 8
Oct 24	Numerical Solution to ODEs	(1) Chap 15
Oct 31	Numerical Solution to ODEs (cont.)	(1) Chap 15
Nov 7	Trajectories & Orbits	Class Notes
Nov 14	Trajectories & Orbits (cont.)	Class Notes
Nov 14	**Class Project Due**	
Nov 21	Numerical Solution to PDEs (**No class on 11/25**)	(1) Chaps 23, 24
Nov 28	PDEs & Fourier Analysis and Oscillations	(1) Chap 17
Dec 7	Fourier Analysis and Oscillations (cont.)	(1) Chap 17
Dec 12	**Take-Home Final due by 5 p.m.**	

Course Description

Computational Physics (PHYS-4007 for undergraduate credit, PHYS-5007 for graduate credit) is designed to cover techniques used in modeling physical systems numerically and analyzing data. It is designed to help the students gain experience with **programming languages** in carrying out this work. It is also important to know how these programming languages are accessed in an **operating system**. Techniques will be developed to numerically differentiate and integrate, and to solve systems of linear equations, ordinary differential equations (ODE), trajectory and orbit problems with numerical methods, partial differential equations (PDE), and finally Fourier analysis. The students also will be introduced to data fitting techniques.

Students should have already taken PHYS-2110/20 (*Technical Physics I & II*) and/or MATH-3200 (*Differential Equations*) before taking this course. Though previous computer programming experience is not required, such experience will be beneficial to the student. We will primarily be using the *Interactive Data Language* (IDL) throughout most of the course, though we will on occasion use Fortran. IDL is one of the easiest programming languages to learn and it has very powerful graphics capabilities and data analysis tools. A tutorial on the use of IDL is given in §III of the course notes. Note that **Appendix A** of the course notes contains a useful reference guide to the Fortran 77 programming language (probably the most widely used programming language in physics and astronomy) and **Appendix B** contains a reference guide to the C programming language.

Computational Physics is a problem-solving course, that is, the measure of a student's progress as demonstrated by the ability to solve numerical problems in physics and astronomy using computer programming methods. Upon completion of this course, the student will possess the basic knowledge of numerical modeling that may be required for graduate school or in a position at a technical corporation.

In this course, the student will be using two different operating systems (Microsoft Windows and Linux) using the computers in Brown Hall Room 264. Besides learning how to solve numerical problems with a computer, the student also will gain experience writing manuscripts in a scientific journal style using the markup language LaTeX. As a matter of fact, this syllabus and all of the course notes are written in LaTeX with the graphics being created in IDL. LaTeX is used by a large number of professional journals, conference proceedings, and textbooks in both the physical sciences and mathematics. Each student will be given a sample LaTeX file to help them get started using this beautiful program.

Due to this, there are two textbooks required for the course: (1) *Computational Physics, Problem Solving with Computers* by Rubin H. Landau, Manuel J. Páez and Cristian C. Bordeianu, published in 2007 by John Wiley, and Sons, Inc.; and (2) *Guide to LaTeX, 4th Edition* by Helmut Kopka and Patrick W. Daly, published in 2003 by Addison-Wesley Publishing Company. I also had the bookstore stock an optional textbook called *Practical IDL Programming* by L.E. Gumley, published in 2002 by Morgan-Kaufmann. I have noted that this IDL book is *optional* since I have useful instructions in the course notes. However, I strongly recommend that buy this book since it will make learning IDL easier. **We will be using IDL a lot in this course!** Below is a list of good reference books in Computational Physics and Programming Languages. Most of these can be found on Amazon (http://www.amazon.com/).

- *Computational Physics*, N.J. Giordano, 1997, Prentice-Hall.
- *Physics by Computer*, W. Kinzel & G. Reents, 1998, Springer-Verlag.
- *Practical IDL Programming*, L.E. Gumley, 2002, Morgan-Kaufmann.
- *Fortran 90 for Engineers & Scientists*, L.R. Nyhoff & S.C. Leestma, 1997, Prentice-Hall.
- *Problem Solving and Structured Programming in Fortran 77*, E.B. Koffman & F.L. Friedman, 1990, Addison-Wesley.
- *A Book on C, 3rd Edition*, A. Kelley & I. Pohl, 1995, Benjamin Cummings Publishing.
- *Introducing C++ for Scientists, Engineers and Mathematicians*, D.M. Capper, 1994, Springer-Verlag.
- *Unix for Programmers and Users*, G. Glass, 1993, Prentice-Hall.

In the world of business, *object-oriented programming*, primarily using the C++ programming language, is used almost exclusively at the present time. However, in the scientific world (and in high-tech industries), what some scientists referred to as *structured programming* (mainly Fortran and some C) is typically used. In both the astronomical and medical fields, the Interactive Data Language (IDL) is often used, mainly due to its rich graphics capabilities. There are many large codes in the scientific community, most of them written in Fortran 77 due to its number-crunching capabilities, that are likely to stay in use for a long period of time. That is the main reason for covering a bit of Fortran 77 in this course as we learn computational physics. Many of the PCs in Brown Hall 264 will have LaTeX and Fortran 77 on the 'Linux side' of these machines (the GNU gfortran compiler), while the Microsoft Windows side' will have IDL

Computer modeling is very complicated and requires years of training to become proficient at it using just one computer language. This brings us to another reason for focusing on IDL and Fortran. I have decades of experience using these programming languages to carry out my research. I want each student to learn how to program to solve problems numerically using computer programs they have written themselves. This type of work can be very frustrating, but becomes very stimulating when one succeeds at it.

Homework, Projects, and Exams

The students will be graded on their performance on a **Midterm** (25% of the course grade) and a **Final** (25%) — the Final is not comprehensive. Both of these tests will be take-home and passed out a week prior to their due date. Approximately 4 to 5 **homework sets** (worth 25% of your course grade) will be assigned throughout the semester. The students also will have to complete a computer **Class Project** which will require a term paper to be submitted describing the code and results. The students will be instructed in the use of the mark-up language LaTeX which is used in many physical science and mathematical journals. The students will be required to write their term paper with LaTeX. The **Class Project** (worth 25% of your course grade) will involve the student through adding programming steps to a template code supplied on the course web page. An 8 to 12 page, single-sided, term paper will be required for this project. Exams, homework assignments, the project paper and associated codes **must** be turned in on the due date no later than 5 p.m. on those days. **There are no exceptions to that rule!** Anything turned in within three days after the due date (again by 5 p.m.) will be reduced by one full grade for that assignment, exam, or project. Anytime after that three day period will result in a zero for that late item.

Honors-in-Discipline and Graduate Students Note: For those of you who are either undergraduate honors students (section 088) or graduate students taking this course, you will be required to include more sophisticated programming steps in the code for the Class Project than the "non-honors" undergraduate students as explained on the project write-up. In addition, these honors-in-discipline and graduate students must write a 10 to 15 page term paper for the project. There also will be additional problems on the exams that the honors and graduate students will have to complete.

Grading Policy

The grading system will be based by the following criteria:

Course Grade = 25%*(Homework) + 25% *(Midterm) + 25% *(Final)
+ 25% *(Class Project)

Each of the items in the formula above represents the normalized score for the given item. The final grades will be based on the following scales. The **Undergraduate Student Scale**:

			A	=	90% or better	**A–**	=	88–89.9%
B+	=	86–87.9%	**B**	=	76–85.9%	**B–**	=	73–75.9%
C+	=	70–72.9%	**C**	=	62–69.9%	**C–**	=	59–61.9%
D+	=	56–58.9%	**D**	=	50–55.9%			
			F	=	Less than 50%			

The **Graduate Student Scale**:

			A	=	90% or better	**A–**	=	88–89.9%
B+	=	86–87.9%	**B**	=	76–85.9%	**B–**	=	73–75.9%
C+	=	70–72.9%	**C**	=	62–69.9%	**F**	=	Less than 62%

Note that a failing grade also will be given if the student has engaged in any form of academic dishonesty.

Mental Health: Students often have questions about mental health resources, whether for themselves or a friend or family member. There are many resources available on the ETSU Campus, including: ETSU Counseling Center (423) 439-4841; ETSU Behavioral Health & Wellness Clinic (423) 439-7777; ETSU Community Counseling Clinic: (423) 439-4187.

- If you or a friend are in immediate crisis, call 911.
- Available 24 hours per day is the National Suicide Prevention Lifeline: 1-800-273-TALK (8255).

For other university information, please consult the ETSU supplemental syllabus attachment at:

http://www.etsu.edu/reg/academics/syllabus.aspx