MODELING AND SIMULATION OF PHYSICAL SYSTEMS

880:205:01

Spring 2009

INSTRUCTOR: Dr. Michael W. Roth

OFFICE: Physics (BEG) 313

OFFICE HOURS: 11 A.M. – 12 P.M. MWF; 3 P.M. – 4 P.M. W

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URL / Class Web Page: http://faculty.cns.uni.edu/~rothm/roth.htm ; then click on "Roth's Spring 2009 Courses"

MEETING SPACETIME INFORMATION: T, Th 12:30 PM – 1:45 PM in PHY 102.

COURSE DESCRIPTION: An introduction to current computer simulation and modeling methods, and their uses in physical and other systems. The first part of the course will be an exploration of some physical models coupled with a few elementary programming techniques for simulation as well as visualization tools. The next portion of this class will be concerned with the application of commercial modeling software as well as parallel programming. In lieu of a comprehensive final exam, each student will present a computational simulation project that amply applies the material covered throughout the course.

NOTE: This course is designed for students with reasonable programming skills and any level of physics preparation. The focus of the programming component of the course is C++ and the textbook provides a nice warm – up and reference to C++ programming if it has been a while since the student has used it, or even if the student has a cursory familiarity with C ++. So if you are rusty at programming, don't worry - the warm – ups and pace of the text should get you up to speed.

OBJECTIVES: The mission of *Modeling and Simulation of Physical Systems* is to foster enthusiasm in students towards numerical modeling and simulation of the world around them, and to see the broader benefit and impact of computer simulations. At a more pragmatic level, the course will help the student prepare for a career in any field(s) where science is an essential component. The successful student will be able to construct models of physical systems, to simulate processes within them and interpret the results within the frame work of the model's limitations as well as anything known experimentally.

REQUIRED READING MATERIALS:

1. *A First Course in Computational Physics and Object – Oriented Programming with C++,* David Yevick, Cambridge, 2005.

PREREQUISITE(S)/COREQUISITES: (810:036 or proficiency in C++ programming and 880:150), or (800:176 and 810:036 or proficiency in C++), or the equivalent.

GOALS: After exiting this class I would like for you (i) to be able to recognize how to simulate physical systems of personal or professional interest; (ii) to be able to use a platform of your choice to be able to construct and run simulations of various systems either with your own coding techniques or with commercial software, and (iii) to be able to visualize the results of your simulations and understand the results against the backdrop of the current state of scientific knowledge.

SPECIAL NEEDS: The Americans with Disabilities Act of 1999 (ADA) provides protection from illegal discrimination for qualified individuals with disabilities. If you have any condition such as a physical or learning disability, which will prevent the fullest expression of your abilities or will require academic accommodations and would like to request instructional accommodation due to disabilities, you must arrange for such accommodation through the Office of Disability Services, 213 Student Services Center, Tel. 273-2676.

GRADING: Exercises involve computer programming homework and one computational simulation project. Performance in the various categories of work will count toward the final grade as follows:

Homework	50%
Project Proposal	30%
Project Presentation	20%

The letter grades corresponding to homework and examination scores may be found from the following standard scale of percentage *cutoffs* for the grades:

93% and above A,	77% C+,	60% D-,
90% A-,	73% C,	below 60% F
87% B+,	70% C-,	
83% B,	67% D+,	
80% B-,	63% D,	

LATE POLICY: Homework sets, exams and projects are due on the dates indicated on the class calendar, with a grace period up through the end of the day on the following Monday. I realize that having a weekend to finish things up could considerably help you, which I am all for! Your work is due on time, with the exception of reasonable documented excuses. *Late work will be docked 10% of face value for each day of tardiness and 50% per day after solutions have been posted.* If you are going to miss a test, you **must** notify me in advance (preferably one week) so alternative arrangements can be made.

ACADEMIC DISHONESTY/PLAGIARISM: Collaboration on homework and certainly labs/activities is welcome, but please keep in mind that your final, turned-in work should be your own and not copied. Although collegiality is encouraged and supported, no form of cheating/plagiarism will be tolerated in this class. If anyone is suspected of academic dishonesty, I will privately speak with them in an attempt to reach a solution to whatever problem is manifesting itself. If anyone is without doubt determined to be cheating on a given assignment/test and no resolution can be offered, *negative credit will be given*. In extreme cases, the Department and/or College administration will become involved.

GENERAL PHILOSOPHY: In a nutshell, I believe in having fun while teaching and learning physics. I want you to do your best in a subject that is not easy. If you get behind and the class feels like a diesel

tractor pulling you through mud, feel free to use me as a resource to help you. Although I love to do research, your learning and class performance is more important! Asking questions in class is strongly encouraged. If you don't wish to ask questions in class please come by my office, give me a call, make an appointment or even send me anonymous e-mail! Also, I like to talk a little about related contemporary issues in class, so if you've found an interesting newspaper clipping or watched a good documentary you'd like to share with us, please mention that. The most entertaining to me are tabloid articles that beg to be de-bunked using physics. I hope you find that physics is everywhere around you and not just in a class you had to take.

EXTRA CREDIT POLICY: Extra credit that adds to your score or substitutes for missed work is not offered in this class. However, I want to encourage you to feel like a part of the Department and I want to expose you to other scientists. Pursuant to that philosophy, I encourage you to go to our seminars, usually at 4:00 P.M. on various Wednesdays and listed on our website at http://www.physics.uni.edu/calendar.shtml. If you turn in one-page handwritten reports to me over the talks, I will keep track of quantity you have turned in. Although not a guarantee, these reports can often be helpful for persons in a borderline grade situation (being within about 1% of a particular grade).

ABOUT THE HOMEWORK: Computational physics has a way of demanding more time than one expects. In general, I recommend that you budget about 15 hours per week for outside work. If you find yourself surpassing this time commitment regularly, please see me for some helpful suggestions.

INSTRUCTOR'S STATEMENT: The instructor reserves the right to modify this syllabus in a reasonable fashion and in the best interest of the class.

MODELING AND SIMULATION OF PHYSICAL SYSTEMS
SCHEDULE – SPRING 2009

Week	Day	Date	Topic(s)	Text Chapter	Item(s) Due
1	T	Jan. 13	Introduction		
	Th	15	UNIX Environment		
2	T	20	Helpful C++ Programs and Visualization tools		UNIX and vi primers
	Th	22	Homework		Homework 1(2.7)
3	T	27	Modifying existing C++ code; Warm–up 1		
	Th	29	Homework and possibly section 4.12 1-8 (fun with others and some chips & dip)		
4	T	Feb. 3	Finite Difference Methods		Homework 2 (5.1, 5.2, 5.7)
	Th	5	Homework		
5	T	10	Monte Carlo Integration; Warm-up 2		
	Th	12	Homework		Homework 3 (15.5, coffee cup and baseball)
6	T	17	Material Point Method		
	Th	19	Homework		Homework 4 (22.1)
7	T	24	Molecular Dynamics and VMD		
	Th	26	Homework		
8	T	Mar. 2	Reflection and discussion of possible projects		Homework 5
	Th	4	Reflection and discussion of possible projects		Project Proposal

Week	Day	Date	Topic(s)	Text Chapter	Item(s) Due
9	T	9	**No Class – Spring Break**		
	Th	11	**No Class – Spring Break**		
10	T	16	Finite Element Methods: Advection / Dispersion Equation		
	Th	18	FEM		
11	T	23	Parallel Programming		
	Th	25	Parallel Programming		Homework 6
12	T	30	Simulink		
	Th	Apr. 1	Simulink		Homework 7
13	T	6	Object-Oriented C++ Programming		
	Th	8	Object-Oriented C++ Programming		
14	T	13	Project reflection and work		
	Th	15	Project reflection and work		
15	T	20	Project reflection and work		
	Th	22	Project reflection and work		
16	T	27	Project presentations		