Physics 432 **Theoretical Mechanics** **Spring 2017**

Class Mtgs: MWF 12:00–1:00 (TREX 272)
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Instructor: Daniel Robb
Office Hours: MWF 10-11, 2:30-4

Course Description:
Developed examination of central force motion, coupled systems, rigid body motion, and the Lagrangian and Hamiltonian formulations.

Textbook:
- *Classical Mechanics* by John R. Taylor, University Science Books, 2005.
  (Note: The ISBN-13 number for this textbook is 978-1891389221.)

Purpose of the Course:
Theoretical (classical) mechanics enables us to understand and predict the behavior of objects as varied as baseballs, rocket ships and red giant stars. Built on the foundation of Newton's Laws, theoretical mechanics incorporates a set of powerful physical concepts and mathematical techniques. These provide valuable physical insight and form the basis for much of the work done in applied physics and engineering.

This course will expand your insight into the physical world, increase your mathematical maturity, and further develop your problem-solving capabilities. You will also gain experience in working with short computer simulations and in using Mathematica (or Maxima, an open-source alternative). I hope that, as you work through the challenging problems this semester, you will also come to appreciate the beauty and elegance of theoretical mechanics.

Intended Learning Outcomes:
1. learn and articulate the fundamental concepts of theoretical mechanics
2. solve challenging problems using advanced mathematical techniques
3. gain facility with computer simulation and using symbolic math packages
4. improve skill in presenting challenging material to a group of peers

Feedback and Evaluation:

I will assign numerical grades to all your work. I *may* curve your final grades (upward), but otherwise you can expect to receive an "A" for 90-100, a "B" for 80-89, etc. I will assign +/- to your final grades by examining the distribution of grades. These are the categories and percentages that will be used:

Problem sets:	40% (6 @ 6.6 % each)
Participation:	10 %
Teaching presentation:	10 %
Tests:	25 % (2 @ 12.5 % each)
Final exam:	15 %

Problem sets are due **at the start of class** on the due date. You will learn the material best by working and persevering with challenging problems. Each problem set will also include a computing exercise of some kind. I encourage you to discuss problem sets with other students, but you must not just borrow a problem solution from another student; you should write up the solution independently.

Participation will include a variety of in-class activities, including problem-solving at the board, computer simulation exercises, and guided worksheets. The grade in this category will be based on completion of these in-class activities, as well as attendance and summaries of two MCSP Colloquium Talks.

Teaching presentation: During the last two weeks of class, you will teach a class on a further topic in theoretical mechanics as part of a team of three students. I will provide a list of suggested topics.

Tests 1 and 2 will cover unit 1 and unit 2, respectively, and will involve problems similar to those in the problem sets. The tests be given in a take-home format over a period of 5 days, and will include a time limit of 8 hours for the total work allowed.

The final exam will be comprehensive (i.e., cover the entire semester) and will also include conceptual questions, including a couple questions on the material in the teaching presentations given by your fellow students.

MCSP Colloquium Series:

The MCSP department offers a series of discussions that appeal to a broad range of interests related to these math, computer science and physics. Members of this class are invited to be involved with all of these meetings; however participation in **at least two** of these sessions is mandatory. Within **one week** of attending a colloquium you must submit (via Inquire) a one-page single-spaced paper reflecting on the discussion. This should not simply be a regurgitation of the content, but rather a personal contemplation of the experience.

Attendance Policy:
You are expected to attend every class. You must be in class to participate in the in-class activities which form part of the class participation grade. If you are going to be absent, I must be notified in advance. If 3 classes are missed without prior notification, then I will assume you are not interested in completing the course and drop you from the class with a grade of DF. You are accountable for all work missed because of an absence. I will provide class materials for a missed class, but will not re-teach a missed class during office hours.

Policy on Late Work:
I will grade an assignment with a 10% lateness deduction if turned in by 5:00PM on the due date. Following that, assignments will receive a further 10% lateness deduction for each successive day late (with days considered to end at 5:00 PM).

Make-up Tests:
Make-up tests will not be given. If you miss a test, and have an official college excuse for that absence, then your final exam grade will count for the missed test.

Academic Integrity:
The College academic integrity policies are vigorously enforced. Although you are encouraged to work in groups on your homework assignments, all work turned in for a grade must be your own. Please familiarize yourself with the College's academic integrity policies.

Disability Support Services:
If you are on record with the College's Office of Disability Support Services as having academic or physical needs requiring accommodations, please meet with me during my regular office hours or schedule an appointment as soon as possible. We need to discuss your accommodations before they can be implemented. Also, please note that arrangements for extended time on exams and testing in a semi-private setting must be made at least one week ***before every exam***.

To register for Disability Support Services, students must self-identify to the Office of Disability Support Services, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact JoAnn Stephens-Forrest, MSW, Coordinator of Disability Support Services, at 540-375-2247 or e-mail her at: stephens@roanoke.edu to schedule an appointment. If you have registered with DSS in the past, and would like to receive academic accommodations for this semester, please contact Ms. Stephens-Forrest at your earliest convenience, to schedule an appointment.

Note: You should expect to spend a combined total of 12 hours per week (on average) on lecture, homework, and reading for PHYS 432.

Class #	Date	Class Topic	Reading	Due
		UNIT 1: Mechanics, Friction, & Oscillations		
1	Jan. 16	Intro, Newton's laws of motion	--	
2	18	Newton's laws in polar coordinates	1.6, 1.7	
3	20	Linear and angular momentum	3.1-3.5	
4	23	Kinetic and potential energy	4.1-4.5	
5	25	Central forces	4.6-4.8	
6	27	Linear air resistance	2.1-2.3	PS 1
7	30	Quadratic air resistance	2.4	
8	Feb. 1	Oscillators with damping	5.1-5.4	
9	3	Driven damped oscillator & resonance	5.5, 5.6	
10	6	Fourier series solution I	5.7	
11	8	Fourier series solution II	5.8	PS 2
12	10	Fourier series solution III	--	
13	13	Coupled oscillators	11.1	
14	15	Normal modes I	11.2	
15	17	Normal modes II	11.3	
		UNIT 2: Lagrangian & Hamiltonian Mechanics		
16	20	Calculus of variations	6.1, 6.2	PS 3
17	22	Euler-Lagrange equation I	6.3	
18	24	Euler-Lagrange equation II	6.4	
19	27	Lagrange's equations of motion **(Take-home I given out)**	7.1	
20	Mar. 1	Lagrange's equations of motion	7.2-7.4	
21	3	Using Lagrange's equations I **(Take-home I due)**	7.5	**Take-home I**
		Spring Break		
22	13	Using Lagrange's equations II	7.6,7.7,11.4	
23	15	The two-body problem	8.1-8.3	
24	17	Equivalent one-dimensional problem	8.4, 8.5	
25	20	The Kepler orbits	8.6-8.8	PS 4
26	22	The Kepler orbits II		
27	24	Hamilton's equations I	13.1,13.2	
28	27	Hamilton's equations II	13.3	
29	29	Phase space	13.4-13.6	
		UNIT 3: Rigid Body Rotation; Group Presentations		
30	31	Moment of inertia tensor	10.1 -10.3	PS 5
31	Apr. 3	Principal axes of inertia	10.4-10.6	
32	5	Euler's equations I **(Take-home II given out)**	10.7-10.8	
33	7	Euler's equations II	10.7-10.8	
34	10	Work on presentations in class **(Take-home II due)**		**Take-home II**
35	12	Group presentation 1	as assigned	
36	14	**Good Friday**		
37	17	Group presentation 2	as assigned	
38	19	Group presentation 3	as assigned	PS 6
39	21	Group presentation 4	as assigned	
40	24	Group presentation 5	as assigned	
	Apr. 26	**FINAL EXAM (Wendesday, 4/26, 8:30-11:30 AM)**		