Physics 416
Advanced Mechanics

Spring Term, 2017
Class Meeting Time - MWF 1:20PM - 2:30PM, Location STEM 040

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Course Description: This class treats various problems in mechanics above and beyond the introductory and intermediate level. We'll cover topics that you likely haven't seen before, of it you have, it was in a cursory fashion. We approach our new topics with an understanding that you are capable problem solvers, independent thinkers, and have taken physics 316 and so are (or quickly will be again) conversant in Octave or MATLAB. You are now equipped with a more sophisticated array of mathematical tools and, thus, we can tackle the REALLY interesting stuff. We'll cover, in rough order, the central force problem, gravity and orbits, relativity, motion in non-inertial reference frames, fluid mechanics, Lagrangian and Hamiltonian mechanics, scattering, non-linear dynamics, and coupled oscillations.

Course Goals: This course represents the completion of your introduction to physics. We have three main goals 1.) Develop advanced concepts in classical mechanics with mathematical and analytical rigor to solve real work problems. 2.) Develop elements of computational techniques that help us conquer big problems. 3.) Continue our quest to be better scholars by developing our problem solving, project management, and communication skills.

On the use of mathematics: I need only quote the great man:

"To those who do not know mathematics it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature... If you want to learn about nature, to appreciate nature, it is necessary to understand the language that she speaks in."
—Richard Feynman (The Character of Physical Law (1965) Ch. 2)

Required Text: *Classical Mechanics, 1st ed.* John R. Taylor (University Science Books, 2005). ISBN-13: 978-1891389221; ISBN-10: 189138922X

Other Texts:

- **Classical Mechanics: A Modern Perspective**, Barger and Olsen

- **The Feynman Lectures on Physics, Volume I**, R. Feynman, R. Leighton, and M. Sands
- **Classical Dynamics of Particles and Systems**, Thornton and Marion
- **Vector Mechanics**, Beer, Johnson, and Clausen

Course Elements

- **Problems** are assigned regularly throughout the term and due dates will be provided. Problems should be neatly written with complete solutions and explanations of your work. Generally, you should outline your approach at the beginning of the solution and offer interpretation and or observations concerning the result of the calculation. Students are encouraged to collaborate, however, each student's solution must be his or her own. The problems will facilitate your learning in this course and need to be done in a timely fashion. In order to incentivize prompt completion of problem sets I reserve the right to penalize for late assignments.

- There will be a large **computational project** for this course. We will be investigating the procession of Mercury's orbit around the sun. We'll complete this project in three stages. In stage one, you'll consider the quasi-analytical problem where we calculate the procession rate using Newtonian mechanics and avoid the many-body problem (write-up due Friday of Fifth Week, 4pm). In stage two, you'll consider the precession but simulating the many-body interaction directly. In this stage, numerical precision will be extremely important as you calculate the precession rate from the orbital characteristics (write-up due Friday of Eighth Week, 4pm). In the final stage, you'll consider the effect of the relativistic force correction to Newtonian gravity (write-up due, at the time of the final). You will each give a **presentation** about your work on this project during the final exam time (Wednesday of finals week, 10am – 12pm).

- Your will be required to **present at least two problem solutions** in class. These will be short presentations but effective ones of your solution to an assigned problem. Presentations should be rehearsed and solutions should be checked with the instructor prior to class. Grades will be based on the effectiveness of the presentation style as well as the quality, completeness and correctness of the solution. Presentation media can (and often should!) be used but must be effective.

- **Participation and attendance** during class is mandatory. While class won't provide everything you need for the course, it's a time for discussion and development of key ideas. Please show up on time. We're a small course and it's a distraction when students don't show up or show up late. Because I feel so strongly that attendance facilitates learning I've given you the opportunity to enhance your grade by simply being in class and asking good questions. Of course, the reverse of that last statement logically follows.

Grading Policy:

You will earn a grade in this class based on the following weightings:

- Problem Sets 35%
- Problem Presentation(s) 10%
- Prompt Attendance/Participation 10%
- Precession of Mercury Problem 35%
- Final Presentation 10%

Office Hours (Tentative):
My schedule for the term is posted outside my office door and is subject to change. I'll make a point to be in my office during the following periods with the expressed purpose of discussing physics related questions:

- Monday, 8am-9am
- Tuesday, 8am-9am
- Wednesday, 10:30am-12pm
- Thursday, 2pm-4pm
- Friday, 8am-9am

Look at my schedule- I have additional flexible time that I'm happy to meet with you to talk physics. Office hours are first come first serve, but other times can be arranged by appointment.

Honor Code

Each student is expected to present his or her own work; however, you are encouraged to work together on the assignments. You should write up your own assignments, but working with classmates to solve problems can be a valuable learning aid. Two ground rules. First, working together is most effective if all individuals contribute more or less equally to the group effort. You should be very wary if you are always on the giving or the receiving end in such effort. Second, when you receive significant assistance through conversation with a colleague, I ask you to follow common scientific courtesy and acknowledge that help briefly in your submitted work.