Classical Mechanics I

Physics 311

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Lecture and Office Hours
Lecture meets on M-W-F from 9:00–9:50 p.m. in Physics 123.

Office hours will be held on M 3–4 p.m., Tu, W 1–2 p.m., Th 3–5 p.m.

Text
Stephen Thornton and Jerry Marion, "Classical Dynamics of Particles and Systems," fifth edition, Cengage Learning, 2003.

additional texts for reference (these can be found in course reserves at the library):

Herbert Goldstein, Charles Poole & John Safko, "Classical Mechanics," third edition, Pearson, 2001.

John R. Taylor, "Classical Mechanics," University Science Books, 2005.

Website
Course information, homework and reading assignments can be found at:

`http://people.reed.edu/~jfrankli/Courses/P311.F26`

Evaluation
Each class meeting will be accompanied by a reading assignment, and two to four homework problems. While the problems will be associated with the lecture, they are not due until Friday at noon (so that each Friday, you will turn in problems that have been assigned on the previous Friday, Monday and Wednesday).

You have spent some time in your laboratory courses thinking about communicating scientific ideas in that experimental setting. In this class, we will also practice our theoretical communication skills in the form of "presentation problems." You must complete two of these longer form written problems over the course of the semester. Every other week I will post two presentation problems by Friday at 5 p.m. Should you choose one of them, the writeup is due by Friday at noon two weeks after they are posted (send a pdf to me via e-mail). The writeups should include (an example can be found at the course website):

- A clear statement of the problem in your own words, and with your own emphasis. (20%)
- The problem's connection to work we have done in class. (20%)
- A clear and correct solution to the problem. (40%)
- Possible extensions or implications stemming from your solution. (20%)

and be no more than three pages long. While only a few students will write up any given presentation problem, everyone should think about and solve these problems.

In addition to homework and the presentation problem, there will be in-class midterms on October 14th and November 23rd. A cumulative 3 hour final will be given during final's week. A portion of that final will cover content from each of the midterms. For those sections, I will take the higher of the two (the midterm and the final section covering midterm material) to count for the midterm "grades."

The scoring break down is:

Homework	20%
Presentation (best of two)	20%
Midterm Exam (10/14)	15%
Midterm Exam (11/23)	15%
Final Exam (portion covering midterms can replace midterm scores)	30%

To quote from Mary Boas's excellent "Mathematical Methods in the Physical Sciences" (3rd ed. John Wiley & Sons, 2006): (replace "mathematics" with "physics" in the current setting) "To use mathematics effectively in applications, you need not just knowledge but *skill*. Skill can be obtained only through practice. . . The *only* way to develop the skill necessary to use this material in your later courses is to practice by solving many problems. Always study with pencil and paper at hand. Don't just read through a solved problem — try to do it yourself! Then solve similar ones from the problem set for that section . . . "

Sage advice — collaboration with peers where it is allowed (homework, in this class) can be useful, but only after you have internalized a problem by thinking about it on your own first. In general, I believe you should start problems by yourself. If, after thirty minutes or so, you have made no headway, contact me (the problem may well be unclear in its statement, or ill-posed) in office hours or via e-mail. After that, think about working with your peers who have gone through a similar process (remember that the work you turn in must be your own).

I would avoid the internet (with its "similar problems" and "hints and suggestions" searches) at all costs, but if you must use it, you must also cite the resources you have used. LLM models and other forms of AI that produce effectively uncitable (and, in many cases, useless) information should not be used under any circumstances, and is not allowed for any component (homework, presentations, exams) of the course.

Course Targets

By the end of the course, students should be able to:

- Solve equations of motion in closed form, where possible, and should know at least one method that could be used to numerically solve with controllable error.
- Extract closed form information about solutions to equations of motion so as to make qualitative or semi-quantitative predictions. Such information might be "perturbative" (i.e. from a similar, simplified problem) or "correct but incomplete" (e.g. information coming from conservation laws).
- Find the equations of motion given a Lagrangian. Identify conservation laws from a Lagrangian.
- Find the Hamiltonian from a Lagrangian, and obtain equations of motion from the Hamiltonian.
- Make quantitative predictions about rigid body motion (in closed form and/or numerically).
- Make quantitative predictions about motion in non-inertial frames (like the one we live in).

- Understand how scattering experiments allow us to probe the structure of interactions.
- Present technical information clearly and efficiently.

Week	Date	Topic
1	8/31	Review of Newton's 2nd law
	9/2	Energy conservation from Newton's second law
	9/4	Examples
2	9/7	**Labor Day**
	9/9	Dynamical systems
	9/11	Bifurcation and chaos
3	9/14	Discretization, velocity Verlet
	9/16	Examples
	9/18	Rotations (transformation)
4	9/21	Orthogonal matrix properties
	9/23	Euler angles
	9/25	Multiple particles introduction
5	9/28	Rigid body motion
	9/30	Symmetric matrix properties, tensors
	10/2	Moment of inertia tensor
6	10/5	Euler's equations
	10/7	Noninertial frames
	10/9	
7	10/12	Centrifugal and Coriolis "forces"
	10/14	Midterm (in class)
	10/16	The variational problem
Fall Break		
8	10/26	The Lagrangian
	10/28	Lagrangian and coordinates
	10/30	Examples
9	11/2	Lagrangian for rigid bodies, tops
	11/4	Lagrangian for magnetic forces
	11/6	Conservation laws
10	11/9	The Hamiltonian
	11/11	Hamiltonian and magnetic forces
	11/13	Examples
11	11/16	Motion in spherically symmetric potentials
	11/18	The $1/r$ potential and Kepler's Laws
	11/20	
12	11/23	Midterm (in class)
	11/25	Bertrand's theorem
	11/26	**Thanksgiving**
13	11/30	Scattering setup/description
	12/2	
	12/4	Rutherford Scattering ($U \sim 1/r$)
14	12/7	Relativistic dynamics
	12/9	