Physics 3351 – Analytical Mechanics – Spring 2025

Instructor: Douglas Durian, djdurian@physics.upenn.edu, 215-898-8147
Lectures: MW 1:45–3:15 in DRLB-A6
Office hours: TIME and by appointment in DRL-2N4

TA: Talia Calazans, calazans@sas.upenn.edu
Office hours: TIME and by appointment in LOCATION

Prerequisites: "((Phys 0150 or Phys 0151) or (Phys 0170 and Phys 0171)) and (Math 1400 OR Math 1410) and Math 2400" Phys 1240 is helpful but not officially required.

Course description: "An intermediate course in the statics and dynamics of particles and rigid bodies. Lagrangian dynamics, central forces, non-inertial reference frames, and rigid bodies."

Textbooks:
(req.) John R. Taylor, *Classical Mechanics* (Univ. Sci. Books, 2005; ISBN 978-1891389221)
(alt.) Thornton & Marion, *Classical Dynamics of Particles and Fields* (about the same level)
(alt.) Goldstein, Poole, & Safko, *Classical Mechanics* (advanced)
(alt.) Landau & Lifshitz, *Mechanics* (advanced)
You should read or at least skim the text prior to lecture, and read it again afterwards to deepen your understanding. Like most upper-division courses, we won't have time to cover all the material in all its subtleties during lecture – so careful reading is mandatory.

Schedule: The first part of the course concerns fundamentals and formalism. We begin with a quick review of Newtonian mechanics. Then we develop two alternative formulations, Lagrangian and Hamiltonian mechanics. The second part of the course concerns applications and specific physical systems. This includes two-body central force problems, mechanics in noninertial reference frames, rotational motion of rigid bodies, nonlinear mechanics and chaos, plus a selection of interesting and important special topics not in textbooks. Towards the end, homework assignments will ramp down as we gear up for term projects (done in lieu of a final exam).

Weeks 0-1	Preliminaries and review (Chs.1-5)
Week 2	Calculus of variations (Ch.6)
Week 3	Lagrangian mechanics (Ch.7)
Week 4	Lagrangian mechanics (Ch.7)
Week 5	Hamiltonian mechanics (Ch.13)
Week 6	Two-body central force problems (Ch.8)
Week 7	review on Mon., midterm on Wed. March 5th (in class, Chs. 1-8, 13)
	Spring Break
Week 8	Mechanics in noninertial reference frames (Ch.9)
Week 9	Rigid body rotations (Ch.10)
Week 10	Rigid body rotations (Ch.10)
Week 11	Nonlinear mechanics and chaos (Ch.11)
Weeks 12-14	catch-up as needed then special topics (fluid forces, hydro/wind power, etc.)

Grading:
50% Homework (generally assigned each week and due on a Wednesday)
35% Midterm Exam (Wednesday March 5th, in class, covering Chapters 6, 7, 8, 13 materials)
15% Term project (due May 13th on topic of your choice)

Homework policies: Homework assignments constitute half of your grade because this is where you really engage and learn the material. Many of the problems will be challenging*, so get started early and be prepared to need more than one attempt per problem. You're encouraged to get help from me and the TA as needed, and to compare answers and general approaches with your fellow students. *But in the end, the work you submit and the thinking behind it must be entirely your own.* Copying or paraphrasing solutions, whether from classmates or other sources, is unacceptable and constitutes academic dishonesty – which Penn takes very seriously. If you are uncertain, the best practice is to state honestly in what way your submission depends on another person or source; proper attribution is a golden rule of academic integrity (at all levels!).

Homework assignments are to be uploaded to our Canvas site by the due date. Late submissions will be penalized 10% per day, capped at 50% deduction.

To emphasize the importance of solving problems correctly and carefully, with no mistakes, each problem will be graded according to the following scheme: You will get 4 points if *everything* is correct (*i.e.*, both method and answer); 3 points if there are any mistakes, including minor ones; 2 points for significantly attempting the problem; 1 point for scant progress.

Exam policies. The midterm exam will be closed-book / closed-note, and will be based closely on lecture and homework material. You may bring one 4x6 in^2 index card as well as pen or pencil and a calculator with no internet or data connectivity. Take alternate seating as space permits, and get settled early so we can start promptly at 1:45pm. Clarifying question are encouraged, but hints /extra information / verification-of-approach cannot be provided.

Regrades. We will make every effort to grade your papers fully and fairly, but mistakes sometime happen. If you think there is a grading mistake on an exam or homework assignment, then write a full description of the issue on a separate sheet of paper, staple it to your work, and submit it to me within one week after it was first returned. Note that the policy for awarding partial credit is not a "mistake" open for discussion or revision. If points were incorrectly added or entered into Canvas, a formal regrade request is not necessary but should still be made within one week.

Honor Code: Any form of copying or cheating or use of AI on assignments and exams is strictly forbidden. On the midterm exam you will be asked to sign a statement that you complied with Penn's Code of Academic Integrity (http://www.upenn.edu/academicintegrity).

Special Situations: There will be no make-ups for missed assignments or exams. Zero points will be given unless you have a valid excuse and have discussed the matter with me in advance.

Students who require accommodation must notify me and make arrangements with the Weingarten Center (https://weingartencenter.universitylife.upenn.edu) well in advance of the midterm.

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* Mary Boas (Mathematical Methods in the Physical Sciences) writes "You need not just knowledge but also skill. Skill can be obtained only through practice. You can obtain a certain superficial knowledge by listening to lectures, but you cannot obtain skill this way. How many students have I heard say, *`It looks so easy when you do it'* or *`I understand the concepts but I can't do the problems.'* Such statements show lack of practice." In analogy, I understand far more about vibrating strings, stick-slip dynamics, and sound than most concert violinists, but I cannot play the violin. I also understand the rules of chess, but I am a poor player.