Physical Mechanics

Fall 2017 | Physics 339 | PEngel 319

Instructor:

Name: Dr. Tom Kirkman General Office Hours: 7:30 A.M. – 5:00 P.M.
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Texts:

- *Classical Mechanics* by John R. Taylor (University Science Books 2005)
  Chapters: 1–11, 13
- `http://www.physics.csbsju.edu/339`

Grading:

Your grade will be determined by averaging six scores: total homework score, three exam scores, and the final exam score (which is double-counted). Assigned homework is due 5:00 P.M. Mondays. Late homework received before Ive completed the grading of the on-time stack will receive a late penalty; homework received after I've graded the on-time stack will not be graded. Day-by-day homework assignments are recorded in the `assignments.txt` file at the class web site. I encourage you to work together on homework and to seek help/hints from me. The exams will consist of a few ($\sim$4) problems. You may use a single-sided $8\frac{1}{2}$" $\times$11" "formula sheet" to assist you on the exam. The formula sheet should be limited to formulas and definitions—no worked examples. Approximate exam dates are: 22 September (Friday), 20 October (Friday) and 20 November (Monday), but I can easily be swayed to move exam dates. The final exam will be comprehensive and have a structure similar to the other exams. The final exam is scheduled for 14 December (Thursday) at 3:30 P.M.. Note that exams and lecture notes from 2014 are available from the class web site.

Questions:

There is no such thing as a dumb question. Questions asked during lecture do not "interrupt" the lecture, rather they indicate your interests or misunderstandings. I'd much rather clear up a misunderstanding or further develop a topic of interest than continue a dull lecture.

Remember: you are almost never alone in your interests, your misunderstandings, or your problems. Please help your classmates by asking any question vaguely related to physics. If you don't want to ask your question during class, that's fine too: I can be found almost any time in my office (111) or the nearby labs. Drop in any time!

Topics:

This course covers 'classical mechanics'. The explanation for motion based on Newton's fundamental equation: $\sum \mathbf{F}_i = m\mathbf{a}$, says that the total vector force determines a particle's acceleration. The word *classical* (in contrast to 'quantum' or 'relativistic') suggests we're mostly concerned with approximating the motion of 'normal' objects (e.g., the apples and planets considered by

Newton). We'll begin with Newton's view of mechanics (PHILOSOPHIÆ NATURALIS PRINCIPIA MATHEMATICA—1687) and then develop the more powerful methods discovered by Joseph-Louis Lagrange (*Mécanique analytique*—1788) and William Rowan Hamilton (1833). While these FDP[1] were limited to pencil-and-paper solutions ('analytical solutions') you'll be solving some problems using the computer program *Mathematica* ('computational solutions').

Many topics this fall should be familiar to you from 191: vectors, conservation laws, SHM, gravity. However the two additional years of mathematics you've completed since 191 will be put to use. Calculus (119 & 120) will be everywhere, Linear Algebra (239) will be the basis for vector and matrix operations (up through eigenvectors), the second order differential equations you studied in 337 *are* $F = ma$, and—as usual—we may be ahead of your Multivariable Calculus (305) class in our use of vector calculus. (Vector calculus will play the leading role in next semester's E&M.)

Some of the class will be devoted to reformulating dynamics. Newton thought of *forces* as the *cause* of motion: $\mathbf{F} = m\mathbf{a}$. Oddly enough we can produce identical results (i.e., identical differential equations of motion) from a very different point of view. (Think about that for a minute: different ideas of 'cause' produce the same predictions... how can science determine which is 'right'?) Instead of $\mathbf{F} = m\mathbf{a}$ we'll use new minimization principles developed by Lagrange which will require some new mathematics: the *calculus of variations*. You're used to using calculus to find *where* (i.e., the x value) an existing function has a maximum or minimum. Calculus of variations is used to find the *whole* function which minimizes (or maximizes) some integral property. For example, consider a twisted (non-planar) wire loop. If you dip the loop in soapy water and then remove it, a smooth surface of soap film will form. What determines the location (z) of the surface at various points inside the loop (i.e., the surface $z = f(x, y)$)? It turns out (to minimize energy) the film adjusts itself to minimize its surface area. So $f(x, y)$ is the surface which, on the boundary of the wire agrees with the actual position of the wire and has less total surface area than any other surface. (Actually the calculus of variations just tells you what differential equation f should satisfy; you then have to solve that diffeq with the methods you learned in 337.)

Oddly enough the main reason we're spending time on these reformulated versions of classical mechanics is that they are needed to understand *quantum* mechanics. So this time next year expect to be seeing Hamiltonians again.

One final point: it is important to remember that the subject of our study is not in the book; it is any object in motion. Spin a penny on your desk any try to explain why it does what it does. Luckily my test questions will not be that hard!

References:

Classical Dynamics by Marion (QA845)

Classical Mechanics by Barger & Olsson (QA805)

Mechanics by Symon (QC125.2)

Analytical Mechanics by Grant Fowles & George Cassiday (QA807)

Principles of Mechanics by Synge & Griffith (QA807)

Newtonian Dynamics by Baierlein (QA845)

Classical Mechanics by Goldstein (QA805) — graduate text

[1]Famous Dead Physicist