Ph 137a – Atoms and Photons
Fall 2019 Course Information

Instructor Nick Hutzler — Bridge 128, x4320
hutzler@caltech.edu — Office Hours: TBD
www.hutzlerlab.com

!! Always feel free to make contact outside of office hours !!

TA TBD

Prerequisites Graduate-level quantum mechanics, e.g. Ph 125abc, or instructor's permission.

Lectures TR 10:30 – 11:55 am, Downs 103
Lectures will not follow a single textbook, but suggested readings will be given throughout the course. See below for a list of suggested books.

Grade 75% Problem sets (lowest score dropped), 20% Final project, 5% Midterm. Minimum grade cutoffs are as follows, though "fair curves" will be implemented.

A+	A	A-	B+	B	B-	C+	C	C-	D	F
95%	90%	87%	84%	80%	77%	75%	70%	68%	65%	60%

Problem sets Weekly sets. Collaboration is strongly encouraged; see below for details.

Collaboration *Short version*: Open everything. All work must be your own, and you must indicate what/whom you consulted. *Longer version*: You are free to consult any textbooks, online resources, people, *etc*., including things like solution sets and course notes for courses at Caltech and other institutions. However, everything submitted must be your own work that you understand and show, and you must indicate any resources/people/etc. that you consulted. Include printouts of any computer code that you used. The only exception to this rule is that you not consult solution sets for this course or previous versions of this course (Ph 103)

Extensions ***Extensions granted only for health, family, emergency, or religious reasons.*** Lots of other homework, preparing for ditch day, *etc*. do not count, but you should always talk to one of us if you are having trouble. ***In lieu of extensions, we will drop your lowest homework grade.*** Request at least one week in advance, if possible.

Midterm There will be a one-on-one oral midterm with Nick. It will not be adversarial, and is primarily a way to check progress and understanding.

Final project Students will research a topic of their choosing (to be decided later), write a report, and present their findings to the class. Details and logistics to be decided as we approach the end of the course.

Honor Code *"No member of the Caltech community shall take unfair advantage of any other member of the Caltech community"* applies to all aspects of this course.

Inclusion Everyone is welcome in this class and at Caltech, and everyone is responsible for creating a welcoming environment. Please contact us with any concerns.

Accessibility Please let us know if you need any accommodations, and we will always help.

Approximate course outline

Feel free to suggest additional topics that you would like to see on the list.

Two-level systems and resonance. Classical and quantum magnetic resonance, rotating frames.

Atomic structure. Hydrogenic atoms, electronic structure, fine and hyperfine structure, multi-electron atoms.

Atoms in static fields. Zeeman and Stark effects, angular momentum coupling.

Atoms in alternating fields. Einstein A and B coefficients, dipole approximation, Optical Bloch Equations, saturation, cross-sections, broadening, M1/E2 transitions.

Cooling and trapping. Laser cooling, laser slowing, magneto-optical trapping, dipole trapping, magnetic/electric trapping.

More complex systems. Raman transitions, adiabatic elimination, atomic clocks, STIRAP, EIT/CPT, fundamental symmetry violations and searches for new physics, optical lattices, and synthetic quantum matter.

Molecules. Born-Oppenheimer approximation, vibrational/rotational structure, angular momentum with an internal frame, response in static and alternating fields, electronic structure/molecular orbitals.

Assorted course policies

This course will use SI units, including factors of $\hbar$, c, ε_0, etc. This is important since we will be relating concepts to experiments, which have units!

Suggested books

There are no required books, but here are some to which I will refer often and should be on reserve in the library. ***The first two books will be especially useful for the problem sets***.

Foot, *Atomic physics*. Good introductory overview, probably worth buying since it is inexpensive.
Budker *et al.*, *Atomic physics*. Not introductory; amazing conceptual discussions.
Natarajan, *Modern Atomic Physics.* Book largely inspired by the MIT 8.421/8.422 notes.
Fox, *A Student's Guide to Atomic Physics*. Good introductory overview.
Weiner and Ho, *Light-matter interaction*. Good, short, introductory overview.
Metcalf and Van der Straten, *Laser cooling and trapping*. Standard text for atom trappers.
Metcalf and Van der Straten, *Atoms and Molecules Interacting with Light*. New version of above.

<u>Quantum mechanics review:</u>

Shankar, *Principles of quantum mechanics*
Sakurai, *Modern quantum mechanics*

<u>Mostly about molecules:</u>

Herzberg, *The spectra and structures of simple free radicals*
Herzberg, *Molecular spectra and molecular structure, vol I: The spectra of diatomic molecules*
Brown and Carrington, *Rotational Spectroscopy of Diatomic Molecules*