Physics 101b. Modern Physics. Professor Dine

Fall, 2004. Syllabus

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Office hours: Monday 1:00-3:00 or by appointment.

Course website: go to department website and click on Dine, or go to http : //scipp.ucsc.edu/~dine Homework and solutions and handouts will be posted here.

Course Description:
Last quarter, you mastered, with Professor Schlesinger, the basics of special relativity and quantum mechanics. This quarter, we are going to apply the things you learned to a range of phenomena in nature.

We will begin with atomic physics. We'll solve the problem of the hydrogen atom. We'll learn to include spin, and then use this to obtain a qualitative understanding of the periodic table. Then we will turn to Statistical Mechanics. Statistical mechanics began with Boltzman, Maxwell and Gibbs. The basic idea is that quite complicated systems, like a gas of molecules, can be characterized by a small number of quantities, like the temperature, which are related to various statistical averages. If you look at such a system, it always looks like some typical member of a large ensemble of possible systems. With quantum mechanics, these ideas really come into their own in surprising ways.

Finally, we will study some of the main areas of present day research in physics. We will spend a good deal of time on condensed matter physics. Then we will turn to Nuclear and Particle physics (the latter being my own specialty). If we have some time, we will talk about astrophysics and cosmology.

Note on the text: the text for this course is *Modern Physics*, by Tipler and Llewellyn. You've been living with the test for a while. I like some aspects of it – if nothing else, it is laid out quite nicely. However, there are a number of things it doesn't do well. It seems to me that too many results are simply presented out of the blue. Many of these are not so hard to understand, and I will try to derive them for you. When I do, I will try to give you handouts (which will also be posted to my website) to supplement the material. These will sometimes be referred to in the homework problems. Generally, the level of the material on the quizzes and exams will be closely tied to that in the book, however.

Books on Reserve: I have placed a number of books on reserve, and may add to the list if it's appropriate. I hope you will take a look at them. They include:

1. *Inward Bound*, by Abraham Pais. This book gives a history of the major developments in physics starting with the discovery of the electron in 1895 and including developments through the 1980's. The book incoludes many wonderful stories and a good deal of insight into experimental and theoretical developments. As its title suggests, the focus is on the understanding of physical law at shorter and shorter distances, so there is not much on condensed matter physics or major technological developments, but there is a good deal on atomic, nuclear and particle physics.

2. The Feynman Lectures, Volume. 3. Feynman has a different way of thinking about quantum mechanics than most textbooks. Less focus on the wave function than on the notion of

probability amplitudes.

3. *Quantum physics of atoms, molecules, solids, nuclei and particles*, by Eiseberg and Resnick. This is another standard Modern Physics textbook. Its treatment of many topics is a bit more sophisticated than that of your textbook and I will be using it from time to time.

4. *Subtle is the Lord – The Science and the the life of Albert Einstein*, by Abraham Pais. Einstein played a crucial role in the development of almost everything we call Modern Physics. This is a wonderful book, including both personal biography and much detail about Einstein's scientific work. (This is the 100th anniversary of Einstein's "miraculous year," 1905.

I will put other books on reserve from time to time as seems appropriate.

Homework, exams,etc: There will be a problem set about once a week. There will be two (announced) quizzes. If things go reasonably well with these, there may not be a midterm.

Tentative Schedule; will be updated as quarter progresses

It is important to do the indicated reading.

Atomic Physics

1. Jan. 4. Schrodinger equation in three dimensions. Separation in rectangular coordinates and solution of some simple problems. 7.1

2. Jan. 6. Schrodinger equation in three dimensions: review of classical mechanics for problems with spherical symmetry. Separation of variables in spherical coordinates. 7.1

3. Jan. 11. Quantization of angular momentum. Quantization of energy for the hydrogen atom and some other problems with spherical symmetry. Hydrogen atom wave functions. 7.2-7.3.

4. Jan. 13. Electron spin. 7.4.

5. Jan. 18. The Total Angular Momentum and the Spin-Orbit coupling. Symmetries of the wave function with two or more particles. 7.5-7.6.

6. Jan. 20. The periodic table. Excited States. Some special topics in atomic physics. 7.7-7.8.

Statistical Mechanics

1. Jan. 25. Classical statistics: the Boltzmann factor and the Boltzmann distribution. 8.1.

2. Feb. Jan. 27. Classical Statistics: The Boltzmann factor and the Boltzmann distribution, continued. 8.1

3. Feb. 1. Quantum Statistics: The Fermi Dirac and Bose-Einstein distributions. Bose-Einstein condensation. 8.2, 8.3.

4. Feb. 3. The photon gas. An application: the Cosmic Microwave Radiation Background. The Fermi gas and applications. 8.4, 8.5.

Molecular Structure

1. Feb. 5. How to think about molecules: the diatomic molecule. Ionic bonds. Covalent Bond. 9.1,9.2.
2. Feb. 8. Other bonding mechanisms. Energy levels of diatomic molecules. 9.3,9.4.
3. Feb. 10. Absorption, stimulated emission. Lasers and Masers. 9.6.

Condensed Matter Physics

1. Feb. 15.The structure of solids. 10.1.
2. Feb. 17. Conduction; free electron gas. Quantum Theory of conduction. 10.2-10.4.
3. Feb. 22. Magnetism. Band theory of solids. Other topics in condensed matter physics (to be decided; superconductivity; impurity semiconductors, semiconductor devices). 10.5- 10.6.

Nuclear and Particle Physics

1. Feb. 24 Basic features of nuclei, alpha, beta and gamma radiation. 11.1-11.4.
2. March 1. The nuclear force and the shell model. 11.5-11.6. Some words about nuclear reactions, especially in stars. Nuclear fusion and fission.

   Particle Physics

3. March 3. Particles and Antiparticles, basic interactions, conservation laws and symmetries. 13.1-13.3.
4. March 8. The Standard Model and Beyond. 13.4-13.5.
5. March 10. Astrophysics and Cosmology.