Physics 420

Principles of Modern Physics

Spring 2008

Instructor:	Dr. J. R. Anderson
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Office Hours:	Tentatively: Tuesdays 10 to noon and Wednesdays 1 to 2 P.M.
e-mail:	banders@umd.edu
Grader:	Dan Schwartz, Office & Ph. to be determined
Textbook:	Serway/Moses/Moyer, **Modern Physics** (3rd Edition), Pub. Thompson/Brooks/Cole

Class Time (Lecture): Tues. & Thurs. 3:30 – 4:45 P.M. Room: Z0405

Lecture Schedule*

	Tues.	Thurs.	Assignment from Serway et al.**	Chapt.	Section
January		29	Intro., Topics in Special Relativity I & II.	1	1.1-1.7
	31		Relativity con.	2	
February		5	Quantum Theory of Light	3	3.1-3.3
	7		Light Quantization, Photoelectric Effect.	3	3.4
		14	X-Rays, Effect of Gravity	3	3.5-3.7
	19	21	Atoms & Matter, Elementary Charge	4	4.1-4.3
	26	28	Atomic Energy Levels, **Review**	4	4.4-4.5
March	4		**Exam I**		
		6	Matter (de Broglie) Waves	5	5.1-5.2
	6	8	Dispersion, Fourier Trans, Uncertainty Prin	5	5.3-5.5
	11		Particle (Wave) Diffraction	5	5.6-5.8
		13	Quantum Mechanics 1D	6	6.1-6.3
	17	21	Spring Break		
	25	27	Particle in Box, CCD, Square Well	6	6.3-6.5
April	1	3	Harmonic Oscil, Expect. Values, Operators	6	6.6-6.8
	8	10	Tunneling	7	7.1-7.2
	15		Applications, **Review**	7	7.2
		17	**Exam II**		
	22	24	Quant Mech 3D,Ang Moment,Hydrogen	8	8.1-8.4
	29		Stat Phys,(Maxwell-Boltz, BE. FE	10	
May		1	Stat Phys con.		
	6	8	Solid State, Metals, Semiconduct, Insulator	12	
	13		Solid State con., Review		

*This is a tentative selection of topics to be covered. Changes in the assignments will be announced in class.

** Not all sections will be covered. Relevant sections will be announced in class.

Course Description

This course is a modern physics course directed primarily toward engineering students. I expect all of you to have an understanding of mathematics through calculus. The lectures will concentrate on covering the major topics and providing insight into the material. There is too much material in the text for a one semester course. Topics will be selected based on the interests of the students (Make selections from the list given out in class) and the "prejudice" of the instructor. **Students are also responsible for material that is discussed in class but is not in the textbook, especially if the subject is emphasized during the lecture. If you miss a lecture, get notes from a classmate or see Dr. Anderson. In fact, you are strongly encouraged to come to office hours or schedule a separate meeting if you have questions. You can make arrangements at the end of a lecture, by telephone, or by dropping by Dr. Anderson's office. *You should not expect a timely response to e-mail, however.* To get the most out of the lectures, it is imperative that you read the text before class.**

Exams will be based on lectures and material in your text. As an experiment, a practice exam will be given out about 1 week before the regular exam. This practice exam should be a guide in your studies of the course material. You may discuss this exam with your classmates and ask about it in class or by coming to my office. At least 40 % of the regular exam will be based closely on the practice exam.

Final Exam

Final Exam Wednesday, 21 May, 10:30 A.M. – 12:30 P.M. (Room Z0405)

[#] Exams are **cumulative**. Makeup exams will be given only for a student with a valid documented excuse (doctor's note, accident report, funeral notice, *etc.*) If you know ahead of time that you will miss an exam you must notify me before the exam. If you miss an exam due to an emergency, let me know as soon as possible. I will be flexible for those with valid excuses who have given timely notification. Makeup exams will probably be given during final week.

Homework and Quizzes

My tentative approach to homework assignments and schedules is as follows: Homework assignments and changes in assignments will be announced in class. You are encouraged to ask about homework during the lectures. Answers to odd-numbered problems are given at the end of each chapter of your text.

Homework solutions in a ring binder will be on reserve and available for study at the Engineering and Physical Sciences Library after the homework has been handed in. Another set will be posted on the bulletin board inside one of the wall cabinets that is just outside the large lecture room (1410). You may make a xerox copy of the solutions at the Library, but, if any solutions are missing from the ring binder, I will no longer provide solutions in the library.

Homework assignments: Chapt 1 – 2, 7, 12, 16, 19, 22, 32, 38.
Chapt. 2 – 2, 4, 8,14, 19, 22. Chapt. 3 – 1, 5, 10, 16, 20, 26, 32, 36.
Chapt. 4 – 2, 6, 9, 16, 25, 28, 34, 37.
Chapt. 5 – 1, 6, 13, 14, 17, 22, 26, 28, 32, 37.

Chapt. 6 – 2, 5, 10, 20, 28, 32, 35.

Quizzes

If a quiz is to be given, it will be announced at least one class period ahead of time and will take place during the final 15 minutes of a lecture. Each quiz problem will be based on a homework assignment.

Help

Help in understanding concepts and solving problems: Discussions with me after class or in my office. I encourage you to stop by my office and see if I am available or you may telephone to set up a meeting time. I think it is helpful to study with others and you may come as a group to my office to ask questions. Changes in my regular office hours will be announced in class.

Grade

Your grade will be determined approximately as follows:
Final exam 30% Two hourly exams 40% HW & Quiz 30%

Active class participation will improve your chances for a higher grade. Course letter grades will be determined approximately as follows: highest 25% - A; next highest 35% - B; third highest 25% - C; lowest 15% - D & F.

Academic Integrity: This University has a student-administered Honor Code and Honor Pledge on the web at http//:www.jpo.umd.edu/aca/honorpledge.htm. This code prohibits cheating on exams, plagiarizing papers, etc. All students are expected to follow this Code.

Students with Disabilities: See me after class or in my office.

1.

Research Developments

R & D August 2005

1. Scanning Electron Microscopy (SEM) with He ions.
2. Intel and new wafer fabrication facility – leading-edge microprocessors in 2007.
3. Nanovalves to trap and release molecules on demand.

4. High performance precision mirrors to focus x-rays and neutron beams.
5. Pittsburgh unveils Big Ben the supercomputer – 2090 processors with peak performance of 10 trillion (10^{10}) calculations/sec.
6. Toyota plans $150 million R&D center near Ann Arbor, Michigan. *(Of course, our Comcast Center cost about the same.)*
7. Retinal implants (artificial) by scientists at USC. Tested in 6 blind patients.
8. BioMEMS (bioelectromechanical systems) developed at nanoscale for applications such as biosensors, cell handling, optical retinal sensing.
9. Silicon optical amplifier and laser demonstrated.
10. World's tallest lab in New York – 416 ft. tall including 13-story cantilever zone.

Photonics – July 2005

1. Photon-Number-Resolving Sensor with ~89% efficiency. Uses tungsten film Operating at 110 mK.
2. Gold nanostructures (~300 nm high and 45 nm in width) act as optical antennas.
3. Self-assembled quantum dots of InAs on a GaAs substrate act as single photon source – coupled to optical fiber.
4. Non-destructive optical test of apple taste.
5. Paper cutting based on infrared diode lasers.

6. High-power Raman lasers for treatment of skin disorders.
7. Photonic instrumentation aids cosmetic measurements.
8. “Making light from a grain of sand.” In other words, using silicon nanocrystals for white-light emitting diodes (LEDs) to replace ordinary incandescent lights.

Energy Problems

1. Use of the compact fluorescent lamp (CFL) to replace incandescent bulbs and save both energy and money.
2. Is hydrogen only a method of energy storage and not a source?
3. We are no longer saving helium, which comes from the oil fields. One important use is for magnetic resonance imaging (MRI). Is this a problem and if so are there solutions?
4. Is ethanol from plants a viable source of fuel?
5. Research on better, i.e. more efficient, lighter, and cheaper, batteries is important.
6. What is the future of solar energy? What materials will we use for solar panels? What about organic thin films? Will concentrators be important?
7. What is the future of nanomaterials and do they have any relation to energy problems?

Standards

1. Time: Rb clocks – how do they work and what is their accuracy.
2. Length: The standard is based on wavelength of light rather than a bar of “meter” length. How accurate is this?

3. What is the standard for mass or force?
4. How do we measure charge in coulombs?
5. How does a global positioning satellite (GPS) system work? How many satellites are "viewed" at one time? What is the resolution (~ 1m)?

Robert Laughlin
A Different Universe (Basic Books)
First Theorem of Science: It is impossible to convince a person of any true thing that will cost him money.

2005 – 100th Anniversary of Einstein's Significant Accomplishments (1905 – Einstein's Magic Year)

The special theory of relativity is actually a "simple law", in fact a symmetry related to relative motion. It was a discovery not an invention. It has been verified by many experiments although most of them have been carried out after Einstein's death in 1955.

The general theory of relativity, Einstein's theory of gravity, however, has not yet been verified experimentally. We think we know the properties of gravitational waves, but they have not yet been observed. At the University of Maryland Prof. Ho Jung Paik has been involved with long-baseline interferometry (LIGO) to search for gravitational waves. Existence of such waves would imply that space is a real medium, although of a very special kind.

It may be ironic to think of the present-day theoretical conception that space is a material substance. The ancient Greeks thought of space as a form of matter, which they called ether. Einstein rejected the either concept entirely when he formulated his theory of special relativity based on electromagnetic fields, but later he accepted the idea that there is an *ether* with special properties.

Physics 420
Spring 2007

Name: _____

Possible Subjects for Class

1. Special Relativity I – Length Contraction, Time Dilation, Constancy of c, Twin Paradox, Reference Frames, Space-Time Plots.

2. Special Relativity II – Modification to Newton's Laws, Dependence of Mass on Velocity, Relativistic Energy, Nuclear Fission, Conservation Laws (Relativistic).

3. General Relativity – Accelerating Reference Frames, Gravitational Waves.

4. Quantum Theory of Light – Maxwell's Relations, Electromagnetic Waves, Black-Body Radiation [Stefan-Boltzmann, Wien, Planck (quantized harmonic oscillator), Photoelectric Effect, X-Rays (Compton Effect), Influence of Gravity on Light (Pound & Rebka-PRL **4**, 337 (1960).

5. Particle Nature of Matter – atoms, electrons, α particles, Bohr Model of Atom (Stationary States), Quantization of Angular Momentum.

6. Wave Nature of Matter – de Broglie Model, Diffraction and Wave Nature of Electrons, Electron Microscopy, Scanning Probe Microscopy, Heisenberg Uncertainty Principle.

7. Quantum Mechanics in 1D – Waves and Probability Density, Schroedinger Equation and Eigenvalues (Free Particle, Particle in 1D Box, Potential Wells and CCDs, Finite Square Well, Harmonic Oscillator, Expectation Value.

8. Tunneling – Reflection and Refraction at a Barrier, Barrier Penetration, Double Well Potential and NH_3), Black Holes.

9. Quantum Mechanics in 3D – Particle in 3D Box, Central Forces and Angular Momentum, Quantization of Angular Momentum and Energy, Hydrogen Atom and Quantum Numbers.

10. Atomic Structure – Orbital Levels and Zeeman Splitting, Spin Magnetic Moment, Spin-Orbit Interaction, Mendeleev Periodic Table, X-Ray Spectra and Moseley's Law.

11. Statistical Physics – Maxwell-Boltzmann Distribution, Equipartition of Energy, Fermi-Dirac Distribution [(2n+1)/2 Spin System, Specific Heat, Free Electron Gas], Bose-Einstein Distribution (n Spin System, Black-Body Radiation), Pauli Exclusion Principle.

12. Laser Manipulation of Atoms

13. Solid State – Bonding, Free Electron Model of Metals, Ohm's Law, Quantum Theory of Metals, Band Theory of Solids, Semiconductors, Semiconductor Devices.

14. Bose-Einstein Systems – Superconductivity, Superfluids (He^3 Trapped Atoms), Lasers.

15. Properties of Nuclei - Nuclear Spins (NMR and MRI), Nuclear Binding, Nuclear Models, Radioactivity, Decay Processes and Half-life

16. Nuclear Reactions – Fission, Fusion, Radiation Damage, Radiation Detectors, Uses of Radiation, Disposal of Nuclear Waste.

15. Elementary Particles – Fundamental Forces in Nature, Particle Classification, Quarks, Standard Model.

Questionnaire for Physics 420. Returning this questionnaire is optional. (It is not necessary to give your name, but I would appreciate feedback.)

Name:

Local Phone:
E-mail Address:
Major:
When did you take your last math course? What was it?

Which physics courses have you taken?

If so, at what level (e.g. was it calculus-based)?

What days and times for office hours would fit your schedule?

If we had weekly review sessions late in the afternoon or in the evening, would you be interested? _____Would you attend?_____ If so, what days and times would be best for you?_____

Although we are expected to cover main topics, I have some flexibility in the material to be covered. Are there any particular things that you hope to get from this course?

Are there any topics you want stressed, or questions you want answered? (This is your best chance to be sure that they will be covered; therefore, be as explicit as possible. Adjustments can be made during the semester if there is sufficient class interest.)