

# **Physics 222 – Introduction to Modern Physics**

**Summer 2007**

**Daily 12:00-1:50 p.m., C247 ESC**

*Modern physics is based upon the two major theories discovered in the twentieth century, quantum mechanics and relativity. Since relativity is covered in physics 123, we will focus on quantum mechanics, including the fundamentals of quantum mechanics as well as studies of atomic, molecular, nuclear, solid-state, and particle physics.*

*Physics 121, 123 (221), 220 (122) or approved equivalents should be taken before taking this course. Students will also be expected to know the mathematical methods used in the prerequisite courses.*

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**Office Hours:** 2-3 p.m. Daily or by appointment  
**Final Exam:** ~~Thursday, August 17 7:00 to 9:00 a.m.~~ Thurs Aug 16, 9-11 a.m.  
**Grade:** 25% Homework, 10% Labs, 20% Exams,  
25% Final, 10% Quizzes, 10% Writing  
**Class URL:**  
<http://www.physics.byu.edu/faculty/durfee/courses/Summer2007/physics222/>

**Important Disclaimer:** Quantum mechanics is unlike anything you have studied before. A lot of the things we discuss will seem extremely strange. They will go against the intuition you have developed interacting with the physical world for two decades of life. Many times you will leave class thinking, “that doesn’t make any sense --- it can’t be that way.” So it is very important, right from the start, for you to put away your prejudices about the physical world.

As humans we have a limited range of senses and are exposed to a limited range of phenomena. In every day life we only deal with objects moving very slowly compared to the speed of light. As such, it wasn’t until Einstein came along that we realized that our intuition for mass, momentum, and energy was incorrect. Humans can only “see” things that occur on time scales longer than a few milliseconds and on length scales larger than a few micrometers. The “Newtonian” intuition for physical law that you develop by throwing balls, dropping objects, accelerating in cars, etc., is based on observations on these scales.

But Newton’s laws emerge from more fundamental laws occurring on smaller scales. The nuances of the more fundamental laws mostly get “washed out” when making larger scale observations, and Newton’s laws do a pretty good job describing things on a human scale. But there are certain ways in which these more fundamental laws make themselves known. Things such as the discrete spectrum of light emitted by atoms gave scientists early clues that Newton didn’t have the full story.

An understanding of these more fundamental laws allows us to understand, predict, and manipulate a larger range of physical systems than we could do with classical physics. But to gain this understanding we have to develop a new way of thinking about physics. So before you read any further, stop and think about the following question for a few minutes: “Why should an atom, which is only about 0.0000000001 meters wide, be bound to my perceptions of physical

law, which were developed by interacting with things on the scale of a meter?” Although some of the ideas in this course will sound counter-intuitive, I promise you that quantum mechanics is not “fringe” science. It is the globally accepted explanation of how the world works. It has been carefully tested with countless experiments. There are still loose ends, and there are many aspects of quantum mechanics which we don’t yet understand. And eventually we will inevitably find a more fundamental set of laws (which will force us to re-wire our brains once again). But until that time quantum is the name of the game, just like Newton was until quantum and relativity came along. Say “I believe in quantum mechanics!” out loud.

**Class Goals:** One of my goals is for each of you to gain the ability to use the ideas and equations of quantum mechanics to understand and solve real problems. In addition to this, I want you to develop intuition for quantum mechanics and, as it were, re-wire your brains to think in terms of a whole new set of rules. This course will also teach you mathematical methods, reasoning, and general problem solving skills. My understanding of science has affected all aspects of my life, from the way I manage my finances to my understanding and appreciation of the gospel. It has sharpened my reasoning skills and awakened a fascination of the universe we live in and of the power that math and science give us to understand and appreciate all of the wonders that surround us. It is my hope that, in addition to learning specific skills in this class, you will also broaden your interest in and understanding of, well... life, the universe, and everything!

This may be the hardest class you take at BYU. I have done a considerable amount of work trying to make it as easy as possible for you to learn the material we will cover, and if you put forth a good effort, you will do well and have fun. Nevertheless, I expect that this will be a challenging course for all of you. You will also have to discipline yourself and study perhaps harder and with greater focus than you ever have.

Studies have shown that two of the most important factors in what a student learns in college are the time spent working with classmates and personal contact with faculty members. As such, I strongly encourage and will do whatever I can to help you to establish study groups and to make myself available to you. Students who have taken advantage of these opportunities in the past have formed friendships which have helped their learning (and their grades) in not only this course but future courses as well.

**Lecture and Review Days:** We meet every day for about 2 hours. On most of those days (typically MWF) I will introduce new physics. You will be expected to complete a reading assignment before coming to class on these days. On other days (typically TTh) we will have reviews, I will discuss your term paper and teach you writing skills, you will get help homework help from the T.A., catch up if we fall behind, etc. There will be some variation from the MWF – TTh pattern, so be sure to check your schedule so that you come to class prepared.

**Text:** The text is *Modern Physics* (Sixth Edition) by Arthur Beiser. The reading assignment for each lecture is listed on the class schedule. To make it easier for me to switch between the term and semester formats, during summer term there will typically be two reading assignments listed for each class period. Please read them both. You will be quizzed on the assigned reading material. It is of great importance that the assigned reading be done before class discussion of the material.

**Homework:** There will be one or two assignments due each Wednesday and Friday and sometimes on Monday. Assignments are due on their listed due date any time before the building closes. Assignments are to be dropped off in the slot labeled "physics 222" in the boxes

near room N375 ESC. You will be assigned an ID number for this course. Be sure to fill this ID number in at the top of each assignment or I will not be able to give you credit for your work. Homework will be returned to the slots next to the box where homework is handed in. It is sorted by the first two digits of your class ID. Other students will have access to your graded homework, so if you don't want others to know your scores, you should not put your name on the assignment (you may if you wish, however).

When your grade is computed at the end of the semester, your two lowest homework scores will be dropped. Because I'm allowing two homework sets to be dropped, ***late homework will not be accepted***. I will bend this rule *only* if a student can prove that circumstances out of their control have prevented them from turning in ***more than two homework sets*** on time. Students are ***strongly encouraged*** to discuss homework problems and to help one another understand the homework, but any assignment handed in must be entirely your own work.

Homework must be legible, and all steps must be clear. If the grader has difficulty following your work you *will* lose points. All homework should be done symbolically as far as possible. When numerical results are required, do not put numbers into your equations until the end. Unless otherwise noted, numerical answers should be given in standard SI (mks) units, and should be given to ***three digits*** of precision.

**Walk-In Labs:** Throughout the semester you will be assigned to perform several short laboratory experiments, similar to the "walk-in" experiments in physics 121. The experiments will be set up in room S415 ESC and will be available for one week (Monday through Friday). You may do the experiment at any time you wish until the building closes on Friday, but I encourage you to avoid the rush and do the experiments as soon as possible. Some of the experiments are computer simulations. These labs are available on the class web page, and you can work them on your own computer or any reasonably up-to-date computer you have access to. Please don't wait until the last minute to find out if it will run on your computer or not.

A worksheet for each lab is available on the web. This worksheet is to be filled out as you do the lab and then handed in. The lab worksheets may be handed in at any time on or before the last day of the lab (make sure you hand them in before the building is closed!). They are to be placed in the same slot and will be returned in the same manner as homework. You are strongly encouraged to work and discuss the labs in groups, but everyone must be present and participate when collecting data and all analysis must be your own work.

**Exams:** There will be two unit exams during the semester and a final exam during finals week. Unit exams will be given in the testing center. There will be no time limits, other than the closing time of the testing center. You will be allowed one 8 1/2" x 11" page of hand written (not photocopied) notes and an *un-programmed* calculator.

The final exam will be given in the classroom at the date and time given above. The final exam will be comprehensive. You will be allowed to use your textbook, any course handouts, your graded homework, exams, and labs, and any notes that you yourself have written. You will also be allowed to use an *un-programmed* calculator. Unless otherwise noted, all exam problems should be worked according to the guidelines given above for homework.

**Quizzes:** There will be several "quiz" and "thought" questions presented in each class period. The first question will be given at the beginning of class, so it is important for you to be on time. The questions will be multiple-choice. In order to participate in the quizzes, you will need to check out a remote from me and register your remote on the class web page. *Quiz questions* will check your preparation for each class, and should not be very difficult if you are caught up on the reading. You will be awarded three points for every correct answer to a quiz question, and one

participation point for every wrong answer. *Thought questions* will be used to help me see how well the class is following the material and to encourage discussion. A participation point will be given for any answer on these questions, regardless of whether your answer is right or wrong. At the end of the day, the total score for your quiz and thought questions will be tallied. Your lowest daily quiz score will be dropped when computing your final grade. As with homework, quizzes cannot be made up. Talk to me ASAP if you have a problem which will result in missing more than one quiz.

**Writing Assignments:** You will be writing a term paper this semester. It will be done in small groups. In addition to handing in a final draft, you will do a group presentation on your chosen topic, and other things will be handed in along the way to help you progress toward a well written paper at the end of the term and to help your writing and presentation skills develop. More information on the term paper is included in a separate document.

In addition to the formal term paper, we will also be doing short in-class writing assignments. At various times during class I will stop and give you a minute or two to write a short but complete paragraph summarizing what we've discussed. I will then randomly pick one student to read their summary to the class. These summaries will help you to internalize concepts and improve your ability to think and write logically. At the end of the semester you will receive ten writing points if you make an honest effort – even if your summaries contain incorrect information. If you don't take the assignment seriously, fail to write, or refuse to present when called upon you will lose points. However, as with any assignment, I will do everything I can to accommodate those with special circumstances or needs.

**Grading:** Your scores will be recorded and available online through the class web page. Please regularly check that your scores are recorded correctly. Your letter grade will be determined from your total percentage, according to the breakdown below. I reserve the right to soften the grading scale, based on my perception of this class's performance relative to other semesters, but I will not raise it (i.e. you are guaranteed at least the letter grade given below for a given percentage).

A:	93-100	B-:	77-80	D+:	60-63
A-:	88-92	C+:	73-76	D:	56-59
B+:	84-87	C:	69-72	D-:	50-55
B:	81-83	C-:	64-68	E:	0-49

**Tutorial Lab:** There isn't an "official" tutorial lab for physics 222. Never-the-less, the T.A.s in the 121, 123, and 220 labs will usually be willing to help you, and every now and then they know the answer. More importantly, the tutorial labs provide a good place to find other students to study and do homework with. As such, I designate the 123 tutorial lab as the official hang out of physics 222 students, and I encourage you to find other students to work homework and study with. You will learn more that way.

**Physics Majors Handbook:** I strongly suggest that all physics majors and minors take a good look at the department's major's handbook. It can be found at <http://www.physics.byu.edu/Undergraduate/handbook.aspx>

**University Policy:** BYU encourages teachers to include the following statements in each class syllabus. In addition, I urge you to review the honor code of the University, found at <http://www.byu.edu/stlife/campuslife/honorcode/>

*BYU's policy against sexual harassment extends not only to employees of the university but to students as well. If you encounter sexual harassment, gender-based discrimination, or other inappropriate behavior, please talk to your professor, contact the Equal Employment Office at 422-5895 or 367-5689, or contact the Honor Code Office at 422-2847.*

*BYU is committed to providing reasonable accommodation to qualified persons with disabilities. If you have any disability that may adversely affect your success in this course, please contact the University Accessibility Center at 422-2767. Services deemed appropriate will be coordinated with the student and instructor by that office.*

*The study of (insert discipline) requires a degree of concentration and focus that is exceptional. Having small children in class is often a distraction that degrades the educational experience for the whole class. Please make other arrangements for child care rather than bringing children to class with you. If there are extenuating circumstances, please talk with your instructor in advance.*