Physics 2220 General Information

Instructor: Dr. Daniel Schroeder
Office: Tracy Hall room 322 (accessed via main Physics office)
Email: dschroeder@weber.edu (best way to reach me)
Phone: 801-626-6048 (voicemail is checked infrequently)
Course web page: http://physics.weber.edu/schroeder/phsx2220/
Office hours: MW 2:30, TTh 10:30, F 1:30. I will often be in my office later than these hours as well, but I usually have classes and other obligations earlier in the day. My full schedule is posted next to my office door. Feel free to make an appointment if you like.

Textbook: You will need a textbook to use as a reference for this class, but the choice of textbook is up to you and we will not follow any particular textbook at a detailed level. A very affordable option is the OpenStax *University Physics* text, which is free in electronic form from openstax.org and also available in hard copy from the WSU bookstore. For this semester you will need volumes 2 and 3. Some good commercially published textbooks include: *Fundamentals of Physics* by Halliday, Resnick, and Walker; *Physics for Scientists and Engineers* by Knight; *University Physics* by Sears, Zemansky, Young, Freedman, and Ford; *Physics for Scientists and Engineers* by Serway and Jewett; and *Physics for Scientists and Engineers* by Tipler and Mosca. Any edition of these books published in the last 20 years or so should be fine, and non-current editions can be obtained over the internet at rock-bottom prices. The only catch is that some versions may lack the material on "modern physics" that we'll cover at the end of the semester (items 5 through 7 below). If you are in doubt about whether a particular book might be suitable, please ask. (All of the textbooks, I'm afraid, are badly bloated.)

Required materials: Everyone will need a scientific calculator; good ones can be purchased for as little as $15. You will also need a ruler and a protractor.

Course Outline

1. **Electrostatics.** We begin this semester with an intensive study of the most important forces in nature: the electromagnetic forces between charged objects. The simplest case, called *electrostatics*, is where the objects exerting the forces are at rest. Even here, the applications are ubiquitous and nontrivial. To deal with these applications, we will introduce a new auxilliary concept: the electric field, which fills the space around charged objects and mediates the force between them.

2. **Electric Currents and Magnetism.** Electric charges in motion are even more interesting than those at rest. Here we study the motion of charges ("electric currents") through wires and other devices, as well as the new forces (called *magnetic* forces) exerted by moving charges on each other. Again we will think of these forces as being mediated by a field, the magnetic field.

3. **Electrodynamics.** When electric currents fluctuate, or when isolated charges accelerate, the surrounding electric and magnetic fields take on a life of their own. A changing magnetic field is always accompanied by an electric field; similarly, a changing electric field is always accompanied by a magnetic field. These phenomena have practical use in tuning circuits and transformers. The most interesting application, however, is to electromagnetic waves: pieces of the electromagnetic field that break free and travel away on their own, at the speed of light.

4. **Optics.** Light is enormously important and surprisingly subtle. Sometimes we can assume it will travel in straight lines, but at other times its wave nature becomes apparent.

5. **Elements of Quantum Mechanics.** Amazingly, light doesn't always behave as a wave—under some circumstances it behaves as a stream of tiny particles. On the other hand, small particles (such as atoms and electrons) often can behave like waves. We'll learn when things behave like what, and use the wave nature of particles to understand why atomic energy levels are quantized.

6. **Relativity.** Puzzling over some apparent paradoxes in electromagnetic theory, Einstein in 1905 proposed that Galileo's principle of relativity might apply even to light—that light might travel at the same speed with respect to *all* observers. But this implied that most of our assumptions about space and time were wrong.

7. **Nuclear Physics.** Quantum mechanics and relativity can be applied in many contexts, but one of the most interesting and most important is the study of the atomic nucleus. We'll investigate nuclear structure, radioactivity, nuclear reactions, and several of the applications of nuclear physics.

There's a problem with topical outlines, though: They tend to give the impression that the course is *merely* a list of topics, one after another. Does this course have any coherent story line or unifying themes?

One major theme is electromagnetism, the subject of about 3/4 of the course. Why spend so much time studying "just one" of the types of forces found in nature? The answer is that our modern theory of electromagnetism accounts for nearly *all* of the phenomena we see around us. It includes the electrostatic forces that hold atoms together, push nuclei apart, and cause your clothes to stick together in the dryer. It describes the electric current that flows through a light bulb, the light that the bulb gives off, and the magnetic generator that caused the current to flow. It explains how you can see yourself in a mirror, talk to a friend on the phone, and watch a television broadcast from a distant city. We'll discuss all of these applications in this course.

Another major theme of the course, though, will be a progression away from the world that we directly perceive and into the universe of extremes: tiny particles, unseen fields, and unthinkably high speeds. Physics encompasses *all* of the physical universe, not just what our limited senses can directly observe. And in seeking to explain matter and energy under more and more extreme conditions, physicists have been forced to cast away prior conceptions of how nature works and replace them with ideas more fantastic than any science fiction writer could have invented.

Goals of the Course

The most obvious goal of this course is that you learn all the specific physics concepts and principles listed above.

But physics not just a collection of specific ideas. It is also a *way* of understanding the world: Strip away the complexity and focus on the underlying mathematical laws! Naturally this approach works better in some situations (How much energy is released by a fissioning nucleus?) than others (Should we invest in more nuclear power plants?). The hardest part of physics is figuring out which *questions* we can feasibly try to answer. In any case, another goal of this course is to help you develop the habit of looking for the underlying physics in as many places as possible, and to give you the confidence that comes from understanding the mathematical laws that the universe obeys.

Along the way, you'll need to practice a number of more specific *skills*: careful thinking and visualizing, making rough numerical estimates, carrying out step-by-step algebraic and numerical calculations, judging whether an answer is physically reasonable, and clearly explaining your reasoning and results. Improving all of these skills is another goal of the course. Whether or not you choose to become a professional physicist, they will serve you well for the rest of your life.

Policies and Procedures

Class sessions will be spent on lecture, demonstrations, example problems, and discussion. *Please interrupt me with your questions at any time.* Attendance is not required but is strongly recommended. Please make sure your cell phone remains silent during class, and refrain from any other activities that your classmates might find disruptive.

Problem sets will be assigned once a week, as indicated on the schedule. The purpose of the problem sets is *not* to test you; rather they are an opportunity for you to practice and learn. I *strongly* encourage you to work with classmates on problem sets. In this way you can learn from each other, prevent careless errors, practice putting ideas into words, and work in an environment more like the "real world". Of course, in the end each of you will be tested individually, so it's best not to rely on classmates *too* much.

I will also make official **solutions** to the problem sets available on the WSU Online (Canvas) web site. You are free to consult these solutions at any time as you prepare your own. However, I recommend that you use them only to *check* your own solutions, and when you are truly stuck. In any case, all work that you turn in must be in your own handwriting.

I will not take the time to read your problem solutions in any detail. Grading will be based mostly on the amount of work completed and the apparent effort expended. It is important that you turn in full solutions, with verbal explanations wherever appropriate (see the official solutions for examples). I will not simply count the number of correct answers.

Late homework will not be accepted. However, your homework grade will be based only on the highest 13 (out of 15) problem set scores, so you may miss two problem sets without penalty. This policy should give you enough flexibility to deal with most scheduled absences, illnesses, family emergencies, term papers, unexpected romances, and the like; exceptions will be granted only in the case of very serious illness or other long-term crisis, and then only if you contact me as soon as possible.

Quizzes will be given at the end of class on the same dates that problem sets are due. Each quiz will consist of one or more problems covering the same topics as that day's problem set. Before each quiz we will have a half-hour question-and-answer session to discuss the homework and prepare for the quiz. No make-up quizzes will be given, but again I will drop the two lowest scores in computing your final grade. All quizzes will be closed-book with no notes allowed. Calculators will sometimes be permitted for doing arithmetic, but may not be used to store any information. Cell phones, tablets, laptops, and similar devices may not be used as calculators or for any other purpose during quizzes.

We will have four **midterm tests**, given in class. Like the quizzes, they will be closed-book with calculators (not including cell phones, etc.) permitted only for doing arithmetic.

The **final exam** will be like the midterms but longer (110 minutes), covering all the material of the course but with an emphasis on the last three weeks. It will be given in class on Wednesday, April 22, starting at 9:00 am (not 9:30!).

No make-up exams will be given without advance permission.

Laboratory exercises will also be an integral part of this course. You should already be registered for a weekly 3-hour lab section. During these sessions you will complete 13 lab exercises, turning in reports on each. You must purchase the lab manual at the WSU bookstore and bring it to your first lab session. Most lab policies are at the discretion of your lab instructor, who will grade your weekly lab work and report each of your weekly lab scores to me. I will then drop the lowest score (allowing you to miss one lab without penalty) when I add up the scores and incorporate them into your final course grade. I may adjust lab scores upward or downward to compensate for inconsistencies in the grading standards of different lab instructors.

You will also take a **lab practical exam** as part of the lab program for this course. Unlike the weekly lab exercises, the lab exam is intended to test your mastery of lab-related skills when you *don't* have lab partners, an instructor, and a lab manual to consult for help. Although the exam will be administered by a lab instructor, for the sake of consistency I will grade these exams myself.

If you are retaking this course and have already completed all of the lab exercises within the last year, you may ask to be excused from repeating the lab exercises and to instead have your earlier lab report scores applied toward your final grade. You must make this request in writing (email is preferred) within the first three weeks of the semester, providing the name of your former lab instructor and the date (semester) when you completed the labs before. Permission to use earlier lab scores is not granted automatically, so you should attend labs this semester while your request is pending. Even if your request is granted, you must still take the lab practical exam at the end of the semester, and it is your responsibility to schedule a time to take it.

Grades will be computed according to the following weights:

Problems sets (highest 13)	10%
Quizzes (highest 13)	13%
Lab reports (highest 12)	12%
Four midterms @10%	40%
Final exam	20%
Lab practical exam	5%

In deciding borderline grades I may also consider class attendance and participation. (It is your *effort* at participation that matters; how much knowledge you demonstrate makes no difference at all.)

Although it is unusual for a student who completes all the assignments to fail this course, I am occasionally forced to give non-passing grades for various reasons. You should be aware that WSU has two different non-passing grades: E and UW. When a student stops attending but does not officially withdraw from the course, the appropriate grade is UW. I normally give a UW to any student who does not pass the course and who has not taken the final exam.

Miscellaneous Rules

You are responsible for reading, understanding, and following the **WSU Student Code**, including its prohibition on all forms of cheating. Cheating on a homework assignment or quiz will result in a zero grade for that item on the first occurrence and failure in the course thereafter. Cheating in any way on a test will result in automatic failure in the course. Cheating (including falsification) in the lab will be handled according to the policies of your lab instructor, with penalties that may also be as great as failure in the course. Evidence of Student Code violations may also be presented to the appropriate hearing committee or the Dean of Students for possible further sanctions.

The Student Code also contains multiple provisions that essentially require you to treat your fellow students with respect, both in and out of the classroom. Inappropriate behavior toward other students will not be tolerated and will be reported to the appropriate authorities for possible sanctions.

All written materials for this course, including quizzes and tests, are covered by copyright law and may not be reproduced, in printed or electronic form, without written permission.

WSU policy permits the making of audio or video recordings during class sessions only with the instructor's permission. Because recordings may capture images and/or voices of other students, there are potential privacy issues involved and therefore I do not automatically grant this permission. If you wish to make a recording, please ask for permission as far in advance as possible.

In the event of a **campus emergency** (e.g., a power outage or unsafe weather conditions) that interrupts the schedule of this class, please check your WSU email promptly for any special instructions.

Any student requiring accommodations or services due to a disability must contact Services for Students with Disabilities (SSD) in room 181 of the Student Service Center. SSD can also arrange to provide course materials (including this syllabus) in alternative formats if necessary.

Hints and Suggestions

The ideas of physics are the most fundamental and universal in science, but they are also the most abstract. Learning physics is therefore unlike learning most other subjects, even in science. Rote memorization might be necessary for the basic definitions, but it won't help you learn to solve physics problems. Looking things up on the internet won't get you far either, even if it's occasionally convenient as a quick reference for the meaning of a word or the half-life of an isotope.

So what ways of studying are there, other than rote memorization and looking stuff up? The answer is *problem solving*: wrestling with how to apply the principles of physics to a new, unfamiliar situation; trying approaches that turn out to be dead ends; getting stuck and frustrated; explaining your frustration to a friend or classmate or in writing to yourself; putting the problem aside for a while so you can make a fresh attempt later; and finally, after enough effort, seeing the way ahead and carrying out the solution. There is no shortcut for this process, and you'll need to set aside plenty of time for it, week after week.

Each idea in this course will build on the earlier ones, so you'll want to make every effort not to fall behind. Don't skip class. If you don't understand something I say in class, ask immediately. Start working on each problem set as soon as we've begun covering the required material.

Finally, try to enjoy the course. Although you may not be completely thrilled by the formula for the electric field of a charged cylinder, there are sure to be other applications that do interest you. Even those sterile electrostatics problems can be fun if you think of them as puzzles to challenge your intellect. To me, the universal principles of physics are truly awe-inspiring, and the conceptual tools that physics develops are immensely powerful. I hope that, as you learn the principles and develop the tools yourself, you will find physics to be as enjoyable, useful, and liberating as I have found it to be.

Best wishes as you continue your study of physics!