SYLLABUS PHYSICS 23, SPRING SEMESTER 2017

INCLUDING PHY 97

PHY 23 is a four-credit course introducing electricity and magnetism, related topics such as electric circuits and electromagnetic waves, and the special theory of relativity. A two-credit option (PHY 97) is available that only covers special relativity, and that has electricity and magnetism (the "EM" part) as a prerequisite. Students taking the class for two credits come to class only twice a week, and will only do the coursework related to special relativity (the "SR" part). Homework, quizzes, and exams will be marked with either "EM" or "SR".

MEETING TIMES

Tuesday and Thursday in LL 511

09:20am-10:10am	Students who take the 4-credit version (PHY 23)
12:10pm-1:00pm	All students, including students who take the 2-credit version (PHY 97)

INSTRUCTOR

Prof. Ivan Biaggio, LL 407
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USEFUL MATERIALS

EM Textbook

Randall D. Knight, "Physics for Scientists and Engineers: A Strategic Approach", 3d Edition, Volumes 3 and 4. Volumes 3 and 4 cover chapters 20 to 37 of Knight's book. We will cover the same material, but not in the same sequence.

SR Textbooks

The first of these books is required, and there will be reading assignments from the second one. The second one is interesting to have and to read in general, but I'll copy the reading assignments.

Thomas A. Moore, "Six Ideas That Shaped Physics, unit R (Relativity)", 2nd Edition.

E. F. Taylor and J. A. Wheeler, "Spacetime Physics," 2nd Edition.

CourseSite

Any other class material is made available on coursesite.

LEARNING OUTCOMES

Initial Competences required for this course (what you should know already)

Before starting this course, students should already be able to describe and predict, quantitatively, the movement of bodies in terms of the forces acting on them (basically the contents of physics 11). Knowledge of vectors and how to use them is also necessary, together with the ability to write and solve algebraic equations, familiarity with the meaning of derivatives and integrals, and ability to write and use integrals. Knowledge of the simplest differential equations and their solutions will also be an asset. Students taking the course for two credits must know about electromagnetism.

Course contents (what I will teach in this course)

In the "EM" part, I will introduce students to electric and magnetic fields, their origins, and their effects. I will explain how those fields are generated, and what they do to electric charges, electric currents, and to each other. I will also explain the origin of electro-magnetic waves, how they relate to light, and quickly review how light propagates through systems consisting of lenses and mirrors and how images are formed. There will also be a short introduction to electric circuits, that is the systems that are obtained when one wires together such elements as "resistors", "capacitors", and "inductors" and sends an electric current through them. In the "SR" part, the course will develop special relativity, and discuss its relationship with electromagnetism. Relativity topics include Lorentz transformations, time dilation and length contraction, and how physical quantities need to be modified in order to be Lorentz invariant. This includes a discussion of space-time, space-time intervals, proper time, four-vectors, energy, velocity, and momentum.

Competences expected after this course (what you are expected to be able to do when done)

After this course, students should be able to analyze both conceptually and quantitatively simple situations involving charges, currents, electric fields, magnetic fields, resistors, capacitors, inductors, electro-magnetic waves, light waves, and the phenomena of electromagnetic induction, diffraction, and interference. This means that students will be able to derive algebraic expressions that allow to calculate the value of physical quantities as they are determined by other physical quantities in specific situations. For example, students will be able to calculate, algebraically and numerically, the magnitude and direction of a magnetic field at a certain point in space when given the values and the coordinates of specific current distributions, or the rate of change of an electric field. As another example, students will also be able to calculate the speed of light, explain its origins and its characteristics, and understand how it relates to the coordinate transformations necessary to move from one inertial reference frame to another. The students will also acquire an understanding of special relativity theory. They will understand how the rate of time-flow and distances change when moving from one inertial frame to the other, how mass and energy can be converted into each other, and how the relativity principle leads to a new mechanics and kinematics of moving bodies.

COURSE GRADING

The final grade of the course will be determined from the total number of "points" collected by the students. These points are obtained in the two four o'clock exams, the final exam, homework, and quizzes:

Homework	150	(accumulated by adding homework points up to a maximum of 150)
Quizzes	75	(obtained from the grades of the best 7 quizzes)
Exams	300	(75 from mid-term 1, 75 from mid-term 2, and 150 from the final exam)
TOTAL	**525**	

Additional extra-credit points that can also contribute to the above total will be given away as "class participation points". The more active you are in class (for example answering and asking questions), the better; The maximum number of extra-credit points collected in this way is 30. Students taking the course for two credits will collect only half the points, but at the end their points will be doubled, so that the above point totals still apply.

HOMEWORK

Regular Homework (HW)

There will be a new homework assignment each week that consists of two parts. A special relativity part and an electromagnetism part. Every such homework counts 6 points, for a total of 12 points.

New assignments are distributed on Tuesdays, discussed on Thursdays, and must be handed in the next Tuesday.

The grading of the homework is based on **effort**, not on correctness. This is how it works:

- You hand in an initial solution
- I look at it, and give it back to you, assigning a number of points between 0 (no effort) to 2 (complete attempt at a solution)
- I provide a solution, either in writing or we derive it in class.
- You then use what you have written before, any comments from me, and the solutions I provided to look at your initial solution again. You then hand it in again, with corrections and comments describing why your approach was wrong. You may add some paper with new work when you do this.
- I look at your final solution and again I assign a number of points between 0 (initial solution was incomplete, and there has been no attempt to improve it) and 2 (all errors where caught and fixed, or maybe there were none in the first place).
- Finally, I assign a number of additional of points, between 0 and 2, that depend on the general quality of the work in both iterations.
- This gives a final tally of 6 points for every homework assignment.

Since there will be an EM assignment and an SR assignment each week, this homework will count for up to 12 points each week. 2-credit students will get only 6, but their points will be doubled at the end.

Learning Homework (LHW)

The "learning homework assignment" (**LHW**) are additional homework assignments that follow another format. They are distributed irregularly in class, you have more time to solve them, and depending on discussions and what we are doing you have a more flexible amount of time to work on them.

The purpose of the learning homework is to stimulate critical and creative thinking and to provide a different way to learn a topic. The aim is not even necessarily to complete it in full, it is to discuss its contents and then work with the solutions to understand what is going on.

The LHW consists in general of a single problem that aims at discussing and teaching some aspects of the material in a different way. Its detailed solutions, distributed later, often go beyond what was asked. Going through these solutions yourself, studying what it offers in addition to what was asked in the LHW assignment, and coming to me with questions about it, is a very important additional way to learn the material.

Grading of the LHW will still work on a 2-2-2 basis with revisions, but instead of providing an initial solution, you must first hand in a "narrative" that explains in words what the physics behind the problem might be and how you plan to solve it. Only after having written the narrative will you start work towards a complete solution that uses equations and math. For grading,

- The narrative counts up to 2 points
- An initial solution counts up to 2 points.
- A self-graded initial solution with comments on mistakes made and additional work counts up to 2 points

There will be a LHW for both EM and SR, and 2-credit students will again see their points doubled at the end.

QUIZZES

There will be one short quiz every week for both the SR and the EM track. Of all the quizzes, only the best 7 of each track will count towards the 75 Quiz points that contribute to the final grade. There won't be any make-up quizzes.

EXAMS

Exams are closed book, but a summary sheet with the most important facts and expressions will be provided, and you can add some small notes for yourself on it. You don't need to memorize any formula.

Mid-Term Hour Tests

There will be two hour tests that will take place during the usual mid-term period. The grade of the hour tests will contribute to the final grade only if it *improves* on the grade of the final exam. No make-up tests will be given.

Final Exam

There will be one comprehensive final exam. The date and time of the final exam are set by the Registrar.

Exam Grade

Grades of all tests and exams will be merged into one total *exam grade*, which will contribute to the final grade as described by the grade distribution given earlier. This exam grade is either the final exam grade or the result of the weighted average between the mid-term grades m_1 and m_2 and the final grade f, with the final carrying twice the wait of a midterm. As an example, the final grade will be calculated via

$$(m_1 + m_2 + 2\, f)/4$$

if the result is larger than the final grade f. But if one of the mid-terms was so bad that it would work against you, then the total exam grade will be calculated via $(m_i + 2\, f)/3$, where m_i is the grade of the other midterm. Or if the grade in the final exam is better than both mid-term exams, then your final exam grade will be just the grade of the final exam. This means that you can do badly in the hour tests and not suffer any consequences if you do well in the final exam.

Beware that this rule should not mean that you don't prepare for the mid-terms. Doing well on the mid-term will alleviate a lot of anxiety because the grade you get helps with the final grade. Also, what you study for the mid-terms is something you won't need to work with as much for the final!

HOW THE VARIOUS ELEMENTS FIT TOGETHER, AND OTHER GENERAL COMMENTS

It is important to realize that this is a fast-paced course which does require *a lot of work*. The rule of thumb when you take a course, is that for every credit hour you need to work *three* credit hours on your own. This course is a 4 credit hour course, and therefore it is totally normal and expected that you work 12 hours a week in order to learn all the required material and in general keep up with the coursework. It is critical that you digest and exercise the material presented during one week before the next week starts.

The material to be learned in this course will come from multiple sources (lectures, recitations, textbooks, homework, reading-assignments). This is a hybrid lecture/recitation course. Classrooms meeting will serve to introduce new concepts and as a guide to the connections between different topics. They will also highlight the most important ideas. But it is expected that students look at the reading assignments in time for the next class, because class time will also be dedicated to homework related to those topics in the reading assignments. Homework assignments solidify what has been introduced in lectures by allowing the students to apply the concepts and techniques they just learned. Homework discussions are where students get a chance to ask lots of questions, and where problem-solving is exercised.

Do not just read the textbook, do not just come to class: this course is ***designed*** for you to learn the material through a combination of reading, attending classes, and the practice in problem-solving that you get by doing the weekly homework assignments. The lecture and the other activities are ***integrated***. I designed how the material that you will learn is transmitted to you via lecture, reading assignments, various kinds of homework assignments, the corresponding solutions, and the examples discussed in class.

Therefore, to profit from this course you must do everything. Sometimes it is useful to introduce a new concept in a homework, other times this happens in a reading assignments or in class. Sometimes there is a deeper explanation of a particular technique in the solutions to the "learning homework". Sometimes we calculate through an example in class, but often you should do your own math, working through examples outside of class. Our limited class time is better used for explaining and connecting concepts instead of detailed number-crunching.

READING ASSIGNMENTS AND HOW TO USE THEM

Reading assignments are provided in the class plan on coursesite (will be updated as we go forward), which details the material that will be discussed in every lecture, and the corresponding sections in the textbook(s). Reading assignments are an integral part of the course. You can go through the reading assignments both before and after the material is handled in the lecture. But everything will be easier if you prepare for each class by looking at the corresponding section(s) in the textbook *before* coming to class. It's as small class and if you read the material before, we can spend more time in a "Q&A" mode. Reading the material before class also helps you acquaint yourself with names and definitions that are required to follow the lectures better. After having discussed the material in class, you can then go back and re-read the relevant sections in the textbook. Nobody understands something by just hearing or reading it once. In fact, reading different explanations by different people is one of the best ways to learn and understand a topic: read explanations from multiple sources, including any other material you might find, on-line or otherwise. Read the textbook, but also read anything else you may find useful, like popular science or history of science in the 19th century (see suggestion at the very end of this text).

At the end of the course, students will be expected to *know the material that is exercised in the homework and that is presented in the corresponding chapters of the textbook even if it is not explicitly discussed in class!* It is worth stressing that, given the time-constraints, it is impossible for me alone to tell you everything that you need to learn, but I can guide you by highlighting the most important things.

I will also provide written weekly summaries of what I do in class.

In summary, scrupulously follow the reading assignments, and don't be a minimalist. You will do best if you read ***more*** than just the textbook sections highlighted in the class plan.

A FINAL ADVICE

Lecture plan and textbooks

In regards to reading the textbooks, a note of advice: do not just read it sequentially. Keep going back and forth and look at sections over and over again. Read the questions at the end of the chapter, and then go back to look for information based on what you can answer and what you can't. Reading sequentially is the worst way to digest the material. In this class I will follow an optimized path through the material, described in the weekly plan provided in advance. This path has been designed to highlight the relationships that may not be seen just by following the textbook sequentially. A counterintuitive advantage that follows from this is also that the reading assignments will not be necessarily sequential, which will help you access the books in an efficient way, and get a feeling of the different ways each topic or physical effect can be associated together. This will in turn be very helpful for general understanding, and will make you better at solving problems because it trains you in seeing relationships. But in addition to the textbook,

do also consider any other source material that you can find, from wikipedia to anything else that you might find useful (see the last section below).

What is this really about?

Part of what is developed during this course is the ability to *calculate* and *solve problems*. This is a valuable skill that will be useful whatever you do in the future. Such a skill is built through *practice*. It is the same as in music or in athletics. Practice is what allows you to master something, and developing problem-solving skills requires practice, alone. There is no other way. We help you to do this by providing homework assignments and discussing them with you.

Another part of what is developed during this course is the *knowledge* of some things that happen in the universe and an *understanding* of how they work. Or how one can use them to do something new. This kind of understanding and knowledge is achieved only when one acquires the ability to see how the various things we will discuss are related to each other. Imagine that what we will learn is represented by some big photograph. It is possible to go through a course like this one and only do the equivalent of analyzing clusters of pixels and their color, or how they are arranged. But true understanding is only reached after you are able to take a step back, and start perceiving the whole picture produced by all pixels together, and learn how different parts relate to each other. It is important to achieve this ability to see the whole picture, while at the same time we work on some details by zooming into it. This is what is very difficult to achieve by just reading a textbook sequentially, and where my role as a guide comes in. By stressing the *fundamental qualitative principles* of the physics we are teaching I will take a spotlight and illuminate the various parts of the picture and guide you through it. Tell you how some physical effects are related to each other, highlight which parts of the textbook are really important, and help you distinguish them from the parts that are just additional descriptions or examples.

The ultimate aim is not just to be able to solve problems in a test. It is to obtain some background knowledge and some work habits and strategies that will be useful later on.

Problem Solving

The basic trap many people fall into because of various reasons, including former training and the way people are tested in school, is the big bear trap of thinking that knowing the material is equivalent to solving the standard problems, with the associated belief that in order to solve a problem one needs to find the formula to do so.

This doesn't work. This has never worked. The very first thing you need to do to solve a problem is visualize it, make a sketch of what is going on, or what you think may happen, decide what basic principles can be used to understand the issues, set up some basic relationships, *and then, once you have an idea about what to do*, start thinking about equations. Equations describing relationships, not pre-canned formulas to find a given quantity. Use algebra for as long as you can. At the end you will get an algebraic expression that represents our solution. Only plug in numbers at the end.

Additional ways to help you learn

To develop the way of thinking that I describe in the paragraph above, it is necessary to develop an understanding of how things "work" in general terms, of how different effects are related to each other, or can be described in a similar way, etc. I will try to give an intuitive feeling in class whenever I can, but you should also look for other sources beyond our classes or the textbook. You can find lots of things just on the web. I found a little, cheap booklet that you can read on the side – like a series of good newspaper articles – and that should help you develop a good alternative explanation of the concepts we teach. This is *"Understanding Physics: Volume 2: Light, Magnetism and Electricity" by Isaac Asimov* for $4 (check the usual on-line bookshops). Get it, read it. I am sure it will help.

A NOTE ON ACADEMIC INTEGRITY, ETC.

Academic integrity applies to all we do. Teamwork on tests is cheating. Doing homework as a team and especially copying the solutions of homework assignments are also against academic integrity: please see the links in the top-left corner when you enter coursesite. In any case, some nice discussions among friends are always a good way to learn and exercise the material, but do try to work on the assignments alone. Always relying on help from others will work against you because it will not allow you to identify the areas where you have more difficulties.

ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

THE PRINCIPLES OF OUR EQUITABLE COMMUNITY

Lehigh University endorses The Principles of Our Equitable Community. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.
[http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]