HOW THE VARIOUS ELEMENTS FIT TOGETHER, AND OTHER GENERAL COMMENTS

What is this really about?

Many different students take this course. Some may be interested in physics. Some may have to take this course as a prerequisite and don't see the reason why. Some may hate the fact of having to take physics. Others may love it. Some will only be interested in their grade, a few won't care too much about the grade but just want to be done with this course and move on to other things. Many will be happy to learn something about how the universe works, others won't care, and others still will see value in learning the techniques.

Because of the diversity of interests in the students taking the course, we need to cover all backgrounds. What I will try to do with this course is help everyone, no matter what their aim is: *give something to the physics lovers to go beyond what's in the standard textbooks, while separating out that material so that it does not bother other students*. Provide a structure that allows to get a decent grade even if not a physics fan – *if willing to do some work and learn something*. Because of this you may sometimes encounter some problems (especially as part of the learning homework) that seems too strange or too difficult, or some other times you may find problems that seem too easy or boring.

An important question is also what will remain after the course is over at the end of the semester. Something that will remain can be the general ability to *calculate and solve problems*. This is a valuable skill that will be useful whatever you do in the future. But such a skill is built through *practice*. It is the same as in music or in athletics. Practice is what leads to master something, and developing problem-solving skills requires doing many problems. There is no other way. We help you to do this by providing homework assignments and discussing them with you.

Another thing that could remain is the *knowledge* of some things that happen in our universe and a *general idea* of how they work (or how one can use them to do something new). This kind of understanding and knowledge is achieved only by acquiring the ability to see how things 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 some selected clusters of pixels and their colors. But then at some point it becomes possible to take a step back, see the whole picture produced by all pixels together, and how different parts relate to each other. Achieving this by just reading a textbook sequentially is very difficult. Rather, I designed the course to have many different complementary aspects. In lectures, I will take a spotlight and illuminate the various parts of the picture and guide you through it. In lectures and in the class plans I'll highlight which parts of the big textbook we must use are really important, and help you distinguish them from the parts that are just additional descriptions or examples. And "deliberate practice" will help pull everything together.

But 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, for those who may keep taking physics course, but also for those who will go into engineering or other fields. This course contributes to the foundations of a house that you cannot see yet, which makes everything hard, but the foundations are what's needed to build a beautiful house.

The work that needs to be done

It is important to realize that this is a fast-paced course which does require a lot of work. ***The rule of thumb is that for every credit hour you need to work three credit hours on your own***. This is a 4-credit course, and therefore it is totally normal and expected that you work an **additional 12 hours a week** to learn all the required material and keep up with the coursework. It is critical that you digest 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). **Lectures** will serve to introduce new concepts and as a guide to the connections between different topics. **Recitations** will go through many examples, and they are the place where you ask questions and exercise problem-solving. **Homework assignments** solidify what has been introduced in lectures by applying the concepts and techniques.

Do not just read the textbook, do not just come to class: this course is designed to learn the material through a combination of all the activities described above. *In other words, the lecture and the other activities are integrated. I designed how the material that you will learn is transmitted to you via lecture, recitations, reading assignments, various kinds of homework assignments, the corresponding solutions, and the examples discussed in class.*

Sometimes it is useful to introduce a new concept in a homework, other times this happens in a reading assignments or in class. 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.

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 in lectures, but I can guide you by highlighting the most important things.

REPEATING SOME ADVICE, AND MORE DETAILS ABOUT HOW TO LEARN

You cannot learn physics without doing lots of independent homework, in particular problem solving. It's the practice of using the concepts that makes you learn and understand them.

Practice problem solving

Getting into the habit of needing "hints" or any other initial help on a homework assignment before trying to do it yourself **is the absolute worst thing you can do**. The most difficult part of solving a problem is finding the right path to work through it. That's what you need to exercise (the *narrative* that is part of the weekly learning homework is meant to help with this).

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 use a particular formula or a specific recipe.

This doesn't work. This has never worked. This will not work in any real-world future activity you will engage in in the future. 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 techniques or equations. Equations are the mathematical description of a *relationship*. Don't look for formulas with the thing you are interested in on the left-hand side. Also, when solving any problem, use algebra for as long as you can. At the end you will get a formula that represents your solution, but it will be an algebraic expression that you derived yourself. Plug-in numbers at the end.

Lecture plan and textbook

My advice is not just to read a textbook sequentially. Instead, use end-of-chapter questions or summaries to jump to certain sections of textbook over and over again, looking for explanations and details. Read the questions at the end of the chapters, go back to look for information based on what you can answer and what you can't. In this class I will follow the path through the material that is described in the plan made available on coursesite. 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 book 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 openstax, to wikipedia to anything else that you might find useful (see the last section below).

Homework points that count towards your grade

Homework points can be collected towards the *150 homework points* that count for the final grade. Do the math: two MP assignments each week of at least 8 points each give (at least) *16 MP points per week*. Over 12 weeks this already gives 192 points. In addition, the LHW provides up to 8 points per week, that is up to 96 points over 12 weeks. So you can collect 288 points thanks to the very minimum of points made available each week from both MP and LHW homework, but you only need 150 to maximize the homework contribution to the final grade. In addition to this, the MP assignments will always have some short questions to quickly collect points, and I will also generally provide more than 8 points for each MP assignment. This means that it won't be an issue if you miss out on one homework because you are sick or because of any other problems, and it also means that you don't have to stress to do every single problem or question that is offered in each weekly homework assignment! You can look at them later, when studying.

Note that the LHW counts towards only 8 of the 24 (or more) weekly homework points you can collect. You should do it because it promotes understanding and discussion, and will help you in the long run. It is not a big deal if you don't solve it completely, but you must try to do as much as you can, and there will be solutions to discuss. Some LHW assignments will have some more challenging parts that are attractive to the most interested students, but they are also useful as review materials and alternative explanations for all students.

Copying

In addition to the academic integrity issues, copying your homework is a guaranteed way to *not* learn the material and to get a bad final grade. And I'd also repeat to **not go look for "hints" about solving problems. You must exercise finding your own way to the solution of a problem.** *There are no "hints" in exams on in real problems* you may face later on. You can go to tutoring sessions and ask for help for understanding what the homework is about, but try doing the problems alone first!! Going to a tutoring class where they give you a recipe for solving a problem that lets you skip the step of actually finding the way towards a solution will leave you with only the math to complete. This would defeat the purpose of homework and work against you in the tests and in anything else.

Also, I must underline that we will not do police work to catch everyone who "finds" the solution of a homework assignment and copies it. But know that you **will** be worse off if you do it. if you copy, you will not learn problem-solving, you will miss important practice, and you will not absorb the material and develop the required skills. If you "find" an old version of a homework with solutions, store it somewhere and try to work on the problem yourself first. If you have troubles, look for info in the textbook, describe your difficulties to your TA, come ask questions.

Additional ways to help you learn

To develop a general understanding of physics, 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. This is the "learn what happens" part. As an example, a basic fact taught in this class is that "an electric field that changes in time gives rise to a magnetic field". Knowing this fact does not require math or calculations. While the aim of the class is to be able to calculate and predict what happens using mathematics, knowing the basic facts already helps a lot. On the other hand, doing calculations without knowing the basic facts that they analyze will never work. It is therefor important to learn "what happens" in much the same way as you would learn a foreign language, and then add the calculations on top of this. I will try to give an intuitive feeling in the lecture 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. Or there are popular science descriptions that will give you a good background about what we will do without using a single equation. There are many resources like this, from newspaper or magazine articles to books. As an example, a cheap, short, well-written booklet that you can look at is Asimov's *"Understanding Physics: Volume 2: Light, Magnetism and Electricity,"* which is available for something like $5 (check on-line).

How to practice physics

In many areas, it has been shown how "deliberate practice" can be essential, and the following is what I think is a good way to implement it when studying physics. Clearly, everyone needs to find their own way, and some things may work better for you than others. But the suggestions below should still be useful.

I suggest **four activities** that all start by looking at old questions and problems. These activities can be done while studying, or in addition to anything else you normally like to do. Which one of these activities you keep doing depends on your personal needs. Here a list, ordered according to the time they require, from least time to more time:

1. Look at old questions/problems and see if you understand the question. ➡ If you don't, or if there is one word you don't understand, look up the material in the textbook and check what it is that you are missing.
2. Look at old questions/problems and see if you understand what are the physical principles that you could use. ➡ If you cannot do this, look up the material in the textbook and find out what you are missing.
3. Look at old questions/problems and see if you can plan how to solve them without actually doing so. ➡ If feel you are missing something, or you are confused about which path to take, look up the material in the textbook or elsewhere. At this stage, if you don't plan to go to try to (4), you can check the solution.
4. Look at old questions/problems and solve them. ➡ If you encounter problems along the way, go back to the textbook and other similar examples to see where the difficulty is. Once your solution is done check it against the solutions that are available. See if you did it right. Understand your mistakes, and why you made them, or what the correct way would have been. Go back to textbook or other materials to get help.

The idea is to build up from (1) to (4), but to do (1) quickly many times before doing (2), and then do (2) many times before doing (3), and so on. This method is makes efficient use of time: it is better to dedicate whatever available time you have to look at more problems as described in points (1) to (3) without calculating a full solution, when compared to the alternative of always trying to solve a problem; because the latter automatically means that you can look at fewer problems. Using this method will also ensure that you are not missing out on some important piece of knowledge or definition. To implement these steps, use the conceptual questions in the book, use any of the problems there, use the additional exercise packs, use old masteringphysics problems, or use old learning homework assignments and their solutions.

Here is what I expect to happen: at the beginning, if your knowledge of the material still needs to be built up, you will find yourself doing point (1) over and over again. Keep doing (1) until you don't need to go back to the textbook or other material anymore and then move to (2). Students with less knowledge-gaps will move quicker to (2). Keep doing (2) until you see that you don't need to go back to other material anymore. Then do (3) and see if the plan you come up with is the one that makes you confident that you can work this out, and exercise doing (4) for some problems.

Once you are further along in your studying, doing points (1) or (2) will take no time at all, and doing point (3) will also become faster.

Note that this is not about doing less problem solving (point 4). It is about doing the same amount of problem solving, but then *deliberately* building up the skills that are part of points (1) to (3) and that are often neglected when studying because standard solutions often focus too much on the math and too little on the physical understanding that allows to arrive at the correct algebra in the first place.

Important: The above only works if you try to answer those questions, and do those problems by yourself. Only after you have tried by yourself (in the variants described in points 1 to 4 above), go seek help or maybe do some of the activities with a colleague. But you can't find out about what you really do not understand if you do not exercise facing those challenges alone.

Naturally, the activities listed above also serve as a springboard to dive into the book (and any other material that helps you), which, as I am sure I already said, is much better than just reading the textbook sequentially.