

1.1: About this Text

Introduction to Text

This is a remix of a remix of a text. Each class is taught a little differently and at Gettysburg College, we have been teaching an introductory physics class for majors that follows the general structure of this text for many years. Our teaching has always emphasized "active learning". This means that instead of passively listening to a lecture, students are actively engaged in the class: Answering questions, discussing concepts with each other, and doing active problem solving on the board. Why teach this way? Simply put, there is an ENORMOUS amount of research that shows that this is the most effective way to learn physics. Strangely, often students do not like it quite as much and they even THINK that they are not learning as much, but study after study shows that they simply learn more when using these techniques. (See [Deslauriers et al., PNAS, 2019](#) if you don't believe me.) Since our goal is for all of you to learn as much physics as possible in the short time we have together, these are the techniques we will use.

Below you will see the original introduction to this text. It explains a lot of what was done with this text originally. A lot of this is true for our class as well with a few exceptions. The most prominent one is that we are not using a "studio physics" model. Instead, this class will be more traditional with regular homework, as many examples in the text that I can write, and in-class exams. However, a lot of the things that are said below are true. The main ones are:

1. You MUST do work before you come to class. There will be little-to-no lecture in class. The Professor will assume that you have read the text before coming to class and are familiar with the basic concepts. If you come into class without having learned the basic material beforehand, the class will not be very useful at all.
2. We will try to do approximately one chapter per day or two days. The chapters are purposely very short to allow for this (and for you to be able to read them the night before in an hour or so).
3. We will not be following a "traditional" order for the text. We will start with conservation laws (the most fundamental concepts in physics) and then move onto Newtonian Physics from there. This makes sense for all of the reasons outlined below.

I have tried to update this text to fit better with Gettysburg College's course. This includes adding problems to the end of chapters (largely from OpenStax) and updating chapters, adding chapters/sections, and fixing a few things I see. Hopefully I actually improve the text, but who ever knows?

I want to thank Professor Christopher Duston for adapting the Gea-Banacloche text to the current iteration and, obviously, Gea-Banacloche (and the OpenStax authors) for the original texts.

If you are reading this, please know that I am constantly trying to improve this text. Please contact me ([kandrese at gettysburg dot edu](mailto:kandrese@gettysburg.edu)) with any errors that you find or suggestions for improvements. This is DEFINITELY a work in progress.

Original Introduction:

This text has been written with several goals in mind:

- Break sections into short chunks appropriate for reading before each class meeting, specifically for use in "studio physics" classrooms.
- Present conservation laws before kinematics.
- Acknowledge that students may be co-enrolled in their first calculus course.

Before proceeding with the text, we will motivate and explain each of these goals. Being an open source resource, this text is constantly in a state of improvement. Feel free to write to the editor, Professor Christopher Duston ([dustonc at merrimack dot edu](mailto:dustonc@merrimack.edu)) if you find significant errors that you think should be corrected.

This text has been written to support a so-called "studio" approach to teaching physics. There are many flavors of this pedagogy (for example, [SCALE-UP](#) from North Carolina State, [Studio Physics](#) from Florida State, and [Studio Physics](#) at The Massachusetts Institute of Technology), but an essential element is that class time is significantly devoted to problem solving over lecture time. To support this, it is necessary for students to be exposed to the material at some level before even entering the classroom. There are several ways to achieve that (this is the so-called "[flipped classroom model](#)"), but it is our feeling that student success is maximized by designing this initial exposure around the studio model, rather than using a traditional textbook. A traditional and carefully constructed 1000-page physics textbook is a beautiful thing, but if the material is broken into sections appropriate for the content, rather than the delivery system, there will be a fundamental mismatch between the goals of the students and the goals of the textbook. So the first goal of this text is to break the content into sections appropriate for single class meetings. At Merrimack

College (where this textbook was designed to be used), there are two class meetings per week, and each meeting tackles one section of this text.

This text was also designed to be the initial source of exposure to the content. Another challenge when using a traditional physics textbook in the studio model is that the first thing a novice reads about might be a completely well-thought out and well-motivated description of a physical law, but a student is likely not prepared for that level of description. The process of learning is not linear and hierarchical, but chaotic and varied. Of course, in the end we want students to be experts a la [Bloom's Taxonomy](#), but starting from the bottom and explaining how they get to the top will not service their own internalized development of the material. To that end, the goal of this text is primarily to provide students with enough material to "soak the sponge", so that when they enter the class they are prepared to learn (and make mistakes!), rather than prepared to solve problems on an exam. To achieve this, the material is presented in a streamlined matter, with simplified motivations and only the first few initial steps spelled out. For sure, this means more complicated material is occasionally only briefly touched upon, and in some cases left out completely. However, we would argue that as a fundamental science, more complicated material in the field of physics can always be added in by instructor demand, in a way that their own students can handle it. And, given that anything can be found on the internet, collecting special topics in textbooks seems like something which has already been done by any number of a myriad of authors. If that's what you want, this textbook is not for you!

The content order of this textbook (conservation laws before Newton's laws) is inspired by the wonderful texts of Eric Mazur and Thomas Moore (in fact, the current version of this book blatantly steals the chapter order from Moore's *Six Ideas In Physics, Units C and N*). For more well-thought out motivations, one can consult those admirable texts - for our part, we will simply motivate this in two ways. First, in many ways conservation laws are more fundamental than Newton's laws. Indeed, the argument about the invariance of specific quantities under time and space translations is so fundamental that it borders on the Philosophical nature of the Universe, rather than our particular approach to modeling it. More directly, equations like $\Delta E = 0$ are scalar and discrete, and therefore typically easier for students to deal with than vector expressions that imply continuous change, like $\Sigma \vec{F} = m\vec{a}$. Second, it is our experience that students have already been exposed to Newton's laws and kinematics - and in some cases have built up significant misunderstandings that are difficult to break down. (A trivial example might be the statement that "the force of gravity is negative!", a viewpoint strongly held by many students. This concept is so rife with intellectual inconsistency that I regret even bringing it up...) By starting students with new, consistently correct ideas about modeling and problem solving in the context of conservation laws, we prepare them to tear down their previous knowledge and rebuild it on a more solid foundation.

Finally, this textbook is written with the knowledge that some (many?) students are going to be stepping into their first physics class while simultaneously taking their first calculus class. This breaks the traditional "calculus before physics" mantra that has been a part of our pedagogy for decades. The source of this change will not be covered here, but we are highly motivated to deal with it rather than preach about its evils from the rooftops. Of course, as a textbook that primarily covers mechanics, it's absolutely true that most of what can be found in this textbook is actually directly derivable from simple ideas based in calculus. However, that is also not usually where students coming to the field are, and it would be an injustice to ask them to climb that mountain before demonstrating the joy of understanding basic concepts in the field. More practically, it is our experience that in so-called "calculus-based physics classes", the biggest challenges for students is not the calculus itself, but the vector algebra and analysis which is utilized in nearly no other field as extensively as physics. Therefore, we do not view the loss of a semester of calculus before this class as a significant barrier, and do not start by assuming students have it. By the second half of the book (Newton's laws), it is assumed that students have a grasp of all the basic notations from calculus.

Open Source Resources and the Construction of This Text

From the outset, we must acknowledge that this text fails in all the goals presented above. Writing a text from scratch is a lengthy business, and we have students to teach! However, since the advent of free and open source educational resources, another avenue has been opened - the "collect, evaluate, and modify" approach. Open source solutions have been available for some time ([University Physics](#) by OpenStax is perhaps the most well-known example, as well as [Calculus-Based Physics](#) by Jeffrey Schnick), but these followed the more traditional order of material. However, once Julio Gea-Banacloche published his fantastic [University Physics I: Classical Mechanics](#), the possibility of satisfying our goals via open source publication became realizable. However, rearranging and breaking apart a textbook comes with it's own dangers, and we are squarely in the middle of those dangers with this text, which was constructed in the following way:

1. Rearrange the Gea-Banacloche text to match the specific order of material, which closely follows Thomas Moore's book.
2. Supplement material which is lacking from OpenStax.
3. Write new material to fill in some gaps.

As such, we owe a great deal of gratitude to both Gea-Banacloche and the OpenStax organization, for making such an approach feasible. However, the responsibility is now all on our shoulders, to continue to modify and develop this book so that eventually we can satisfy the lofty pedagogical and practical goals we outlined at the beginning of this section.

Whiteboard Problems

In our studio classroom, over half the time is spent solving problems on whiteboards in groups. During this time, the instructor (and typically one or two learning assistants) are on hand and available to assist if a group gets stuck. Over the years, we've developed many more of these style problems than we will typically use (3-4 per class period, generally), so we've included the extras in this text. At the end of each chapter we will have an "Example" section, and these whiteboard problems will be presented there (along with some good examples from the two main source texts we discussed above). These can be used identically to example problems, or they could be used as actual whiteboard problems for a studio classroom. In the future, we are planning on adding our entire set of whiteboard problems to these sections - this will correspond with a generally shortening of the actual texts of the chapter, to match our goal of being accessible as a pre-class reading assignment.

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