# 1.1: About this Text

This text has been written with several goals in mind:

- Break sections into short chucks 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) 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 then 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 then 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, each class meeting is about two hours long, 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 then 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 then Newton's laws. Indeed, the argument about the invariance of specific quantities under time and space translations is so fundamental that it boarders on the Philosophical nature of the Universe, rather then 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 then 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 then 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 then 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.