

Chapter i

Preface I: For Faculty

and For People Doing independent Study

Physics One, The Alpha Edition is based on the decades I spent teaching this course as a college professor. This book represents a radical change in how we teach physics. Why is this book different from many other introductory mechanics books? Most important, students can probably afford to buy it. In some states, this book costs less than the sales tax on some of its competitors. That's possible because this volume is independently published, using my figures and editing skills. My illustrations are the sort of line drawings I would put on the blackboard during lecture.

Physics One presents calculus-based, college-level physics. By calculus-based, I mean that students must consistently use calculus in homework. They should also need calculus in examinations, but that is under your control, not mine. By college-level, I mean that for the most part the course is based on symbolic, not numerical, reasoning.

Why is this *The Alpha Edition*? I spent considerable time proofreading and fact checking. However, this volume costs so little because it is not being used to support a vast horde of artists, photographers, editors, proofreaders, indexers, marketeers, salesmen, Vice Presidents, expense accounts, corner offices[1], consultants, and other doubtless nice people. Correspondingly, despite my best efforts, there are doubtless remaining typographic errors, infelicities of phrase, and other mistakes I failed to remove. I would much appreciate your calling these to my attention, at phillies@4liberty.net, following which at some future date I shall be replacing *Physics One, The Alpha Edition* with *Physics One, The Beta Edition*.

You will hear colleagues say that many freshmen are not yet reasoning on the symbolic level, the level where they would solve problems using algebra and calculus rather than plugging numbers into their pocket calculators. To that I say students came to the university to learn new things. For those students, symbolic reasoning is one of those things that they need to learn, and that you and your colleagues need to teach them. To help students learn symbolic reasoning, the book presents a lot of algebraic calculations, in which I take very small steps from line to line, so students can follow the steps for themselves. I try to emphasize why steps are being taken. In addition, I provide almost no numerical problems, only algebraic and calculus-based problems. For each Chapter in Part I, I present a set of self-test questions for students, with solutions provided at roughly the level of detail I would have presented the solutions myself in a conference class. These solutions present new material not in the rest of the chapter.

Physics One has as its foundation one rule and two equations.

The one rule is: Physics is based on *praxis*, learning to get the right answers for the right reasons. A wrong method that happens to give the right answer is wrong. Read Section 3.3 Motion at Constant Acceleration to see where an alarming number of students have learned wrong methods.

The two equations are

$$\mathbf{F} = \frac{d\mathbf{p}}{dt} \tag{i.1}$$

and

$$\text{PHYSICS} - \text{CALCULUS} = \text{NONSENSE}. \tag{i.2}$$

The first equation is Newton's Second Law of Motion. Your students may have seen it written differently. Don't worry if they don't recognize my notation. After we finish the first few chapters, they will understand

the symbols I just used.

The second equation is the main reason this book is radical. I say: To understand physics, you must use calculus. This book assumes that a student can take integrals and derivatives of a few standard functions: sin, cos, exp, log, polynomials, and powers, and is familiar with the product and chain rules.

The second equation implies that students have to some extent studied calculus before they pass far into this text. Many High Schools now cap their math sequence with calculus, so that your students may well have seen the needed derivatives and integrals (and probably a considerable number of less useful integrals and derivatives). At a few colleges, students may be taught with the Kingsbury approach, in which students learn how to take derivatives and integrals of, e.g., polynomials, first, and turn to limits and analysis later; those students with some coordination may know enough calculus by the time they need it. If you are studying physics independently, you need to learn some calculus first.

Corresponding to the expectation that students learn and use symbolic reasoning and calculus in homework and exams is the need for student homework to be graded so as to learn how to use symbolic reasoning and calculus. That's quite different from homework sets in which students only need to supply the right answer. Serious attention to grader performance will be needed.

Part I of the text develops basic mechanics. The experiments in Part II of the text are usefully done in parallel with the theoretical development in Part I. Part III develops harmonic oscillators; those can be challenging to study with experiments unless there is an appreciable equipment budget.

The course follows the lectures and recitations sections I taught for many years at the Worcester Polytechnic Institute. Our academic schedule was atypical. Terms ran seven weeks, a week including three lectures, two recitation sections, and two hours of laboratory. Three of the lectures were used for exams. Homework was assigned to be collected in every lecture including the first, and was returned in the next recitation section or lecture. Students took three courses at a time; they were expected to spend 10-15 hours a week outside of class studying and doing homework. Approximately speaking, each chapter in Part I corresponds to a lecture. The Lab Exercises in Part II represent a novel approach based on using minimum equipment. The Chapters in Part III on harmonic motion, are organized by topic, and represent multiple lectures each.

Finally, I found a path to involve all students in answering non-rhetorical questions (you can now duplicate my scheme electronically, but my method, like my book, costs much less.) I would pose a question, and list on the board several answers, labelled A-B-C-D. Students had each been issued a large sheet of paper labeled A-B-C-D in its four corners. I gave ample time to think and then told them all to pick up the paper by the corner matching their answer. They all answered at once, so they all had to think. Yes, my "obvious" answer was usually the wrong answer. *Cognitive dissonance* is an enormously powerful teaching tool.

A closing thought on homework problems: Over the term, students should work a large number of homework problems. To simplify grading, I used statistical sampling, grading one of the three or four problems on each homework set. The Grading for 20 homework sets was 6 - solution process and final answer are correct, 4 - solution process is correct but there are modest errors, 2 - solution process is wrong but all problems had serious attempts, and 0 - homework was wrong, seriously incomplete, or missing. This process generates a grade. It keeps things simple enough that there is no common excuse for a grader not to finish everything immediately, and eliminates more or less all disagreements about how many points an answer is worth.

Finally, some words of thanks: Word processing and formatting were done with L^AT_EX, namely WinEdt overlaying MikTeX, including various American Mathematical Society packages. The drawings, generated with Inkscape, are very close to what I would have put on the blackboard. I should specifically thank Cedar Sanderson for calling my attention to Inkscape, George Grätzer for his series of L^AT_EX volumes especially *More Math Into L^AT_EX*, long-time friend Rich Moore for suggesting that I rewrite the introduction, and above all generations of students whose questions, comments, and especially mistakes did much to improve this work.

[1] OK, I confess. My working office, upper floor of my home, has picture windows on two sides.