

Prospectus for the *Essential Physics* package.

Essential Physics is a new textbook and learning package aimed at the College Physics audience, covering the standard introductory physics topics without using calculus. The package consists of the following components.

- An innovative textbook, written in a user-friendly format.
- A student workbook that can be used in class to help increase the interactivity of the classroom setting, in a recitation setting, or by students on their own time.
- A set of Powerpoint presentations designed for classroom use, complete with clicker questions.
- A collection of custom-designed simulations and animations that can be used during class time to accompany clicker questions and to help students visualize the physics concepts they are learning about. The simulations can also be used in other settings, such as by students outside of class. A workbook to accompany the simulations is also planned.
- An accompanying web site with additional readings and example problems, the simulations, and sample test questions for the students.
- A set of end-of-chapter problems and questions designed to test student understanding of the concepts.
- Problems and questions for on-line homework systems.
- An instructor's guide that includes suggestions for in-class demonstrations to be used to help illustrate concepts, and to bring the physics to life.

The *Essential Physics* package has been class-tested, and continually refined, by me, the author, (Andrew Duffy, at Boston University) for several years during the development of the materials. The writing of *Essential Physics* is my response to the growing frustration I felt in using other books. First, the students did not seem to be getting much out of their textbook (I tried a few different ones), if they read the book at all. Second, I did not feel that the book supported my efforts as I introduced new pedagogical techniques (such as clicker questions, and a focus on understanding concepts) – for instance, the end-of-chapter problems did not generally reward conceptual understanding. In *Essential Physics*, I have tried to create materials that support good pedagogy. The book is focused, easy for the students to read, and it provides end-of-chapter exercises and other tools (such as Powerpoint presentations with built-in clicker questions) that support what you do in the classroom as an instructor.

Over the next three pages, let's look at some typical problems faced by instructors in the College Physics course, and how these problems are addressed by the *Essential Physics* package.

Problem 1: Students don't read the book.

The Essential Physics solutions

- **The innovative format of the book.** Each chapter section is presented in a two-page spread format. On two facing pages, students are introduced to a concept, then either work through an Example or an interactive example known as an Exploration, followed by a summary and a conceptual question about the concept. The students can see everything they need about a concept without turning a page.
- **The engaging writing style.** The book is written in a friendly, conversation style, to minimize the intimidation factor many students feel when they take Physics.
- **The way the book engages the students in the learning process.** Rather than having the students sit back and look at how the problems are solved in the text, the Explorations invite the students to participate in the discovery of the concepts.
- **The length of the book.** The book is about 75% of the length of most other books in this market.

The goal is to make the book inviting and appealing for the students, so that they will want to use it to learn the material.

Problem 2: Students don't learn how to solve problems.

The Essential Physics solutions

- **An emphasis on step-by-step problem-solving methods.** One of the keys to solving many of the standard Physics problems is to apply a problem-solving method with a few basic steps. After going over a method, and solving example problems following the method, the students practice it by working through end-of-chapter problems that follow the method.
- **An emphasis on conceptual understanding** in the text, as well as in the end-of-chapter exercises. In the *Essential Physics* book, confidence is built through a set of conceptual questions. Armed with a conceptual understanding, the students should get the confidence they need to attack the more difficult problems.

Armed with a solid conceptual understanding, and with confidence gained by practicing problem-solving methods, the students should be better able to solve problems.

Problem 3: Students don't see the big picture.

The Essential Physics solutions

- **Focus.** In the *Essential Physics* book, the emphasis is on fundamental concepts, so it is obvious to the students what is really important.
- **Linking topics.** In many books, each new chapter is treated as a new topic, unrelated to what came before. In the *Essential Physics* book, links between topics are emphasized so that students see how everything fits together. For example, understanding one-dimensional motion provides the basis for understanding two-dimensional motion, and understanding how objects with mass interact via gravity gives a solid foundation for understanding how charged objects interact.
- **A unified approach.** All the components were written by the same author, which unifies the components in a way that is not done with competing packages. For instance, the student workbook, the simulations, and the in-class Powerpoint presentations and clicker questions in the *Essential Physics* package are tightly coupled to the material in the book.

The goal is for the students to appreciate how different Physics topics fit together and complement one another to give us a deep understanding of how the world works.

Problem 4: Students learn in different ways.

The Essential Physics solution

- **An emphasis on visualization and multiple representations.** Students have different learning styles, so looking at a situation from various perspectives can increase comprehension. In addition to the diagrams and graphs in the book, the package of simulations also helps bring the concepts to life for the students.
- **The use of non-traditional problems.** By supplementing traditional problems with activities such as ranking tasks, students have multiple opportunities to demonstrate their conceptual understanding.
- **Directly addressing common student misconceptions.** Despite different learning styles, research has shown that students have common misconceptions. These are addressed in *Essential Physics* in multiple ways, so that all students come out with correct conceptions.

The idea is that in appealing to students from several perspectives, the students can understand a concept from at least one perspective, and expand their comfort zone by seeing how other perspectives complement what they are most comfortable with.

Problem 5: Students are not actively engaged in the learning process.

The Essential Physics solution

- **An emphasis on interactive engagement.** A key result of Physics Education Research is that gains in student learning can be obtained by increasing the level of interactive engagement. Instructors who want to actively engage their students have tools that they can use in the *Essential Physics* package, including the Powerpoint presentations with clicker questions included, the student workbook which can be used by students in the classroom in a peer-instruction environment, and the simulations, which can be used in class by the instructor and outside of class by the students.
- **Explorations.** Some of the concepts presented in the book are presented not through explanatory text, but instead through what are called Explorations. Explorations are used in various ways, sometimes including parts that elicit a students' prior knowledge, ask students to make predictions, and/or lead students through the thought process necessary to introduce or understand a concept. In essence, an Exploration is part Example and part guided inquiry designed to engage the students in the discovery of various concepts.

The goal is to actively engage the students in the learning process.

Problem 6: Instructors don't have much time for teaching preparation.

The Essential Physics solution

- **The Essential Physics package includes all the components** an instructor needs to be up and running in the classroom immediately. This includes a set of Powerpoint presentations with embedded clicker questions, simulations that can be used in class, and questions for on-line homework systems.
- **An instructor's guide**, including suggestions of demonstrations to do in the classroom.
- **The end-of-chapter exercises support conceptual understanding**, enabling instructors to create assignments that are true tests of how much of the material the students have mastered.

The idea is that, with little time and effort, instructors are ready to use the *Essential Physics* materials in their classes.

Features of the *Essential Physics* book

The book has been designed with the idea of engaging the student in the learning process and the goal of helping students to truly understand the key concepts. The pedagogical tools that are used to promote such engagement include:

- **Explorations.** These are Examples in which the student is actively engaged in the learning process.
- **Key Ideas.** Each Exploration ends with a Key Idea box, in which the basic concept addressed in that Exploration is summarized. These help to focus the student on the main idea addressed in an Exploration.
- **Examples.** Many students learn physics by focusing on the example problems in the textbook. In the examples in *Essential Physics*, special care is taken to not just focus on equations (a pitfall for many students), but to help students see how the equations support the underlying concepts.
- **Related Exercises.** Some end-of-chapter exercises are designed specifically to accompany each Exploration and Example. This provides the student with an opportunity to assess for themselves whether or not they understand the concepts and methods discussed in a particular Exploration or Example.
- **Essential Questions.** Each section in *Essential Physics* concludes with a Question and Answer pair. This is another feature that is designed to engage the students in the learning process, asking them to stop and think about one concept before they turn the page to learn about something else.
- **Problem-Solving Methods.** In introductory physics there are many cases in which an entire class of problems can be solved by applying a particular problem-solving strategy. In such cases the students are presented with a step-by-step method to apply and they then see at least one example of how the method is put into practice. A unique feature of *Essential Physics* is that there are several end-of-chapter problems associated with each of the problem-solving methods. These are designed to train the students in applying a particular method.
- **Chapter Summaries.** The chapter summaries are not simply lists of all the equations presented in a particular chapter. Key equations are included, of course, but they are supported by a summary of the important underlying concepts. Most chapter summaries also include a step-by-step problem-solving strategy, useful for solving a particular class of problems.

Student web site: <http://physics.bu.edu/~duffy/EssentialPhysics/>

The student web site is designed as a key component of the *Essential Physics* package. The site will have several features, including:

- Simulations and animations to accompany the material in the printed text.
- Additional worked examples.
- Additional topics, such as a section on Kepler's Laws to accompany the Gravitation chapter.
- Sample problems, with solutions.

Whereas the content of the student web site that accompanies a text is generally fixed, the web site for *Essential Physics* should be viewed as organic. If you have an idea for a particular simulation, a particular example problem, or a particular on-line section, feel free to suggest that to the author. If you are even more inspired and would like to create your own simulations, problems, or on-line sections, links from the *Essential Physics* site to your material can be included so that others can benefit from your work.

Also, the Instructor's web site for *Essential Physics* will not just be a repository of materials. It will include an electronic bulletin board to promote collaboration between instructors using the *Essential Physics* materials. You can post ideas of how to use the materials, ideas for good demonstrations to use in class to promote student understanding, etc., and get feedback both from other instructors as well as the author.

About the author

Andrew Duffy is an Assistant Professor of Physics at Boston University, where he has taught introductory physics (both algebra and calculus-based) for eleven years. He is particularly interested in investigating how technology can be used to enhance the learning experience, both in and outside of the classroom. For example, he has scripted a large collection of Physlet simulations that he uses on a daily basis in class and which students have access to on-line, and he also uses a PRS classroom response system every time he teaches to promote interactive engagement. He was the principal investigator in a three-year NSF-funded project that involved setting up two 12-station microcomputer-based laboratories for use by the introductory physics students at Boston University, and he is currently the principal investigator in a second NSF-funded project aimed at bringing in new experiments to enhance the educational experience of students in the intermediate and advanced undergraduate physics courses at Boston University.

Other current projects include acting as a faculty mentor in a Boston University NSF-funded GK-12 program, and being a co-leader in a program to train in-service high-school teachers, who are not currently qualified to teach physics, in the teaching of physics. Andrew Duffy was named the winner of the 2004 Neu Family Award for Excellence in Teaching in the College of Arts and Sciences at Boston University.