Preface

Waves: An Interactive Tutorial is a set of 33 exercises designed to teach the fundamentals of wave dynamics. It starts with very simple wave properties and ends with an examination of nonlinear wave behavior. The emphasis here is on the properties of waves which are difficult to illustrate in a static textbook figure. Simulations are not a substitute for laboratory work. However they allow for visualization of processes that cannot normally be seen (for example electric and magnetic fields). They allow for visualization of process that are too fast (for example waves) to follow in real time or too small to see (for example thermodynamics at the molecular scale). They allow manipulation of processes which might be dangerous (collisions) or hard to experiment with (waves). They also allow for easy repetition. For all of these reasons, simulations are an excellent way to introduce students to the complex phenomena of waves.

The tutorial may be used in conjunction with a text or as a stand-alone introduction to waves. Exposure to calculus and basic physics is assumed in the latter sections. The material was constructed in such a way that the student is required to actively work their way through the material instead of passively reading printed text at a low comprehension level. The objective is to replace the traditional textbook for the course (but not necessarily replace the entire course) with computer aided instruction that requires active learning on the part of the student. The goal was to create a guided text that integrates the strengths of printed, static textbooks and the interactive dynamics of the Internet to engage the student in actively learning the physics of waves.

Play the above simulation and observe the propagation of the wave along a beaded string. How can this motion be expressed mathematically? What would happen if the string is attached to a wall? What happens if the mass of the beads is increased? We will develop answers to these and related questions in this tutorial but what is as important is the mental image gained from a visualization of the phenomena.

Interactive Engagement

We have known for sometime that active teaching methods work better than lecturing in the classroom. (See R.R. Hake, "Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses", *Am. J. Phys*., Jan. (1998)). Many instructors now use collaborative group work, lecture demonstration, Socratic dialog and other interactive techniques in their classroom. But what about the textbook? Students now have access to electronic textbooks for sale or rent but these are still mostly static (pdf) files. All that has been done is to speed up access to the same material that existed in hard copy. Except for the introduction of color pictures, not much has changed since Guttenberg's time.

Physics textbooks are notoriously hard to read. In Student Evaluation of Teaching (SET) score results, the perception of the physics textbook ALWAYS receives the lowest score, regardless of which text is chosen or who teaches the class. When (if?) students read the text, what do they get out of it? Do they actively engage in the subject or do they just look at the words and pictures? Some research evidence hints that, at least for physics, students don't get much from a traditional textbook but rather depend on the instructor to interpret for them because they do not know how to read a physics book. But what if the textbook required answering questions and manipulating computer simulations as the student worked through a topic? The goal of this tutorial is to explore the possibility that a textbook which required the student to be engaged would lead to better student understanding of the material; to make a better textbook, an *active learning textbook*.

In the education world the Internet and course management technology is still too often used as a one way communication tool, simply making it a bit more convenient for students in a conventional course to receive the same or similar material which previously was handed out in class. But the same technology can be used as a two way communication tool where students are actively engaged in manipulating course material, controlling both simulations and live experiments, collaborating with other students and interacting with the instructor. Many of these activities can be done in a laboratory setting as an integral part of a regularly scheduled course, performed asynchronously as homework assignments or completed as a component of a new hybrid kind of distance learning course.