Preface

This book is written for an audience that is very diverse in its learning styles, and my objective is to expose the readers to different and unique ways the basics of wave motion can be studied in an academic setting. Why such a title? There have been many books written about waves, and quite a few are sufficiently successful in covering and teaching a wide range of topics to provide exposure to the physics of wave motion. There are books about waves in general and specifically about light and about sound that convey the basic ideas that all waves follow.

Because most of these books emphasize the coverage of topics from an authoritative perspective, they have neglected the student perspective.

By student perspective I mean one where the ability to apply the ideas is inseparable from being exposed to their basic definitions. From my experiences as a physics student and instructor, the traditional presentation has been that the didactic approach often neglects the context.

In the science education literature researchers have known for some time that from the earliest experiences, humans tend to be better observers when they are interested. Correspondingly, it seems logical to suppose that a learner being provided with a context stands a better chance of understanding the material, rather than being introduced to it without one.

Understanding a concept involves much more than simply memorizing and regurgitating the information. The application of concepts places a learner in a situation where more is required than a simple recollection of information. To this extent, the role of inquiry must be actively incorporated into instructional materials, if one hopes to appeal to that natural need of a context.

Inquiry-based instruction needs to place the learner in a position of relative ignorance, although some guidance needs to be provided; the reason for this guidance is to allow the learner to utilize whatever background information he or she possesses. There are many views on the importance of inquiry, some claiming that it doesn't show substantial gains in the learning of difficult concepts. Many studies, however, have shown a clear advantage for nontraditional students to be engaged in inquiry-based instruction.

Consider an example using light and sound as sources of information to explore and understand the world. Generally speaking, events do not become experiences until there is awareness, and the experiences become more meaningful when there is reflection upon them. Suppose you are seated outdoors and hear a bird singing by emitting short bursts of a high-pitched sound and you want to locate the bird; there will be an interaction between the waves that make up what you see and what you hear. Both types of waves undergo similar processes as they get to you, for the most part; however, you will not experience them all due to various properties, such as the length of the waves, how they propagate, what other objects do to these waves when struck by them, and so on.

If you were an ornithologist, you most likely would know what type of bird it is, since the example is about hearing it but not seeing it. Additionally, you could probably tell whether it is a female or male, how old it is, its size, etc. However, if you were not an expert on bird watching, you would need to rely on the sound to guide your vision if you hope to see it. There are some things you could ascertain about the bird from prior experience, such as its size and even its type. For one thing you can deduce that if the sound is high pitched, the bird is not a crow, which would also make it easier to spot. Based on this, you conclude that the bird is small. If there are several trees having lots of branches and leaves, this makes the task more difficult since you seem to hear the sound coming from various directions. As you continue to listen, you begin to concentrate on an area where you think the sound is coming from based on what you hear; however, if the bird were to stop singing, you would be extremely hard pressed to find it.

You could probably come up with a better example than this to provide a setting; what I have done is to create a scenario and provide an experience. I believe that is the essence of the term inquiry, the provision of opportunities to experience phenomena and to explore them based on what one knows beforehand.

The way in which this book deals with the incorporation of inquiry is by its lack of distinction between theory and practice. As soon as a concept or an idea is introduced, an attempt is made to provide opportunities for exploration. Whether the task is one of concept development or quantitative determinations, to provide opportunities to explore lies at the heart of inquiry-based instruction.

Additionally, the text incorporates laboratory experiences into the introduction of the content; while this has been done before, the types of experiences are both physical and virtual. There is an undeniable benefit to being able to manipulate variables in a setting that does not require extensive preparation and where the data obtained can be processed in real time.

There are many tasks involving simulations, predominantly using one of the very best sources publicly available (*PhET Interactive Simulations*, *University of Colorado*, *http://phet.colorado.edu*).

Some of these virtual experiments can be done as extensions to the class discussions; in other words, these activities can be assigned as homework projects, thus enhancing the opportunities for inquiry and investigation they make available.

The simulations have been structured to allow the user to exercise both pace and variable control; studies have shown that simulations can often overwhelm students with low prior knowledge, due to quick and continuous changes that can overload working memory. Variable control can be particularly helpful in the development of exploration and hypotheses testing.

At the same time, the need for physicality is not neglected. Physics is and hopefully will always remain an experimental science; despite great advances in technologically rich environments, there is a basic need for physicality. The role of kinesthetic tasks is an area of considerable interest due to the findings concerning student retention and understanding of the material. To this extent there are nearly 20 experimental tasks included that require physical manipulation of variables.

I have endeavored to demonstrate that the approach taken in this book will benefit all readers, particularly those among you that tend to be intimidated by scientific concepts. I don't know what the readers' experiences have been, but mine have consistently shown me that there are many more students from the sciences who are interested in the arts and the humanities, than it is the other way around. I sincerely hope that with this book I can help change that!

I believe instructors cannot afford to neglect their responsibility to the audience (students); there are simply too many great and interesting aspects of waves that all students should be allowed to understand, since they will enrich their understanding of their preferred areas of study.

Instructors can decide on how to cover the material given their individual circumstances. The book has been primarily, although not exclusively designed for non-science majors, and students must possess some algebraic proficiency. If the instructor finds that students struggle with quantitative information, my recommendation is to concentrate on those chapters that don't require a significant amount of mathematical detail. However, don't neglect the value of exploratory tasks found in such chapters, since they may be more palatable and instructive for those students without requiring mathematical expediency.

There is no particular sequence needed to expose students to the many interesting aspects and applications of waves. Therefore, if some chapters must be omitted to facilitate student comprehension that may be hindered by a lack of algebraic proficiency, this would not constitute an obstacle for students to develop a basic understanding of wave motion.

Based on my experience with a class of non-science majors that needed a science course to fulfill a general education or distribution requirement, I decided to cover only the first six chapters.

When teaching the properties of light or those of sound separately, one can find applications in all chapters, and so it is a matter of choosing the relevant aspects to the topics that are found throughout the text. Given this scenario, it is quite feasible to cover at least the first nine chapters in a given semester.

Instructors can also choose chapters that they consider appropriate for their particular student audience. The first nine chapters are undoubtedly driven by content-specific properties of waves, while the last three are concerned mainly with a variety of applications that utilize many of these concepts and properties. Therefore, instructors can provide students with an overview of all the topics, by concentrating on the exploratory tasks exclusively. The narrative sections that often precede these tasks can be assigned as part of the background knowledge to successfully carry out the tasks.

Figures 2.1, 2.3, 3.4, 3.9–11, 4.1, 4.4, 4.6–11, 6.1, 7.8, 8.3, and 9.1 were constructed using Physical Science Images & Art (Qwizdom Inc.) used with permission.

Credits: Fig. 10.2-credit: Wikimedia Commons, Fig. 10.10 and that of the Exploratory Task on p. 196-courtesy of Imgur.

Long Island, NY, USA Fernando Espinoza

Springer
http://www.springer.com/978-3-319-45756-7

Wave Motion as Inquiry
The Physics and Applications of Light and Sound
Espinoza, F.
2017, XIII, 232 p. 201 illus., 176 illus. in color.,
Hardcover
ISBN: 978-3-319-45756-7